# JOURNAL

OF THE

# BOSTON SOCIETY

OF

# CIVIL ENGINEERS

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## VOLUME 3

## 1916

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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
Names of authors are printed in *italics*.

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CIVIL ENGINEERS
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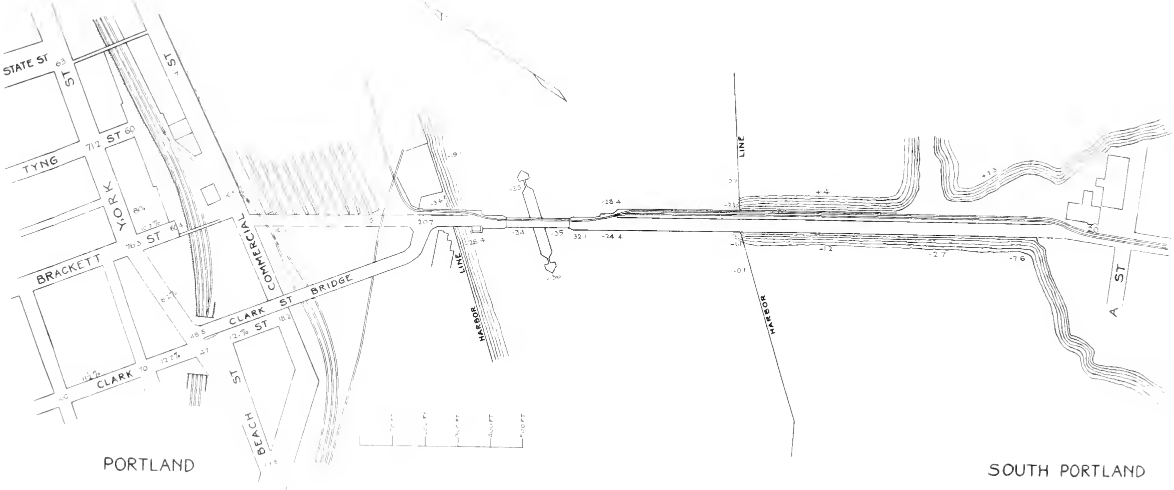

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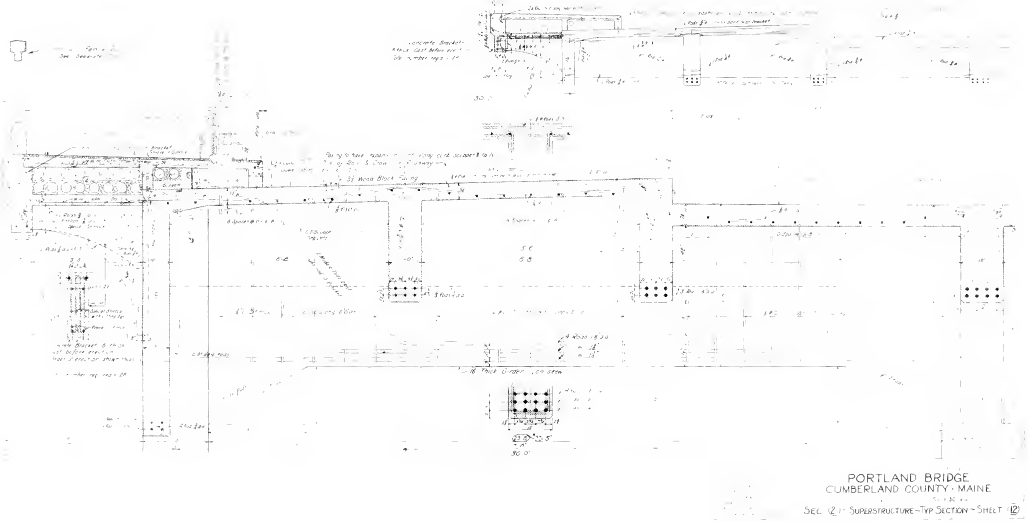

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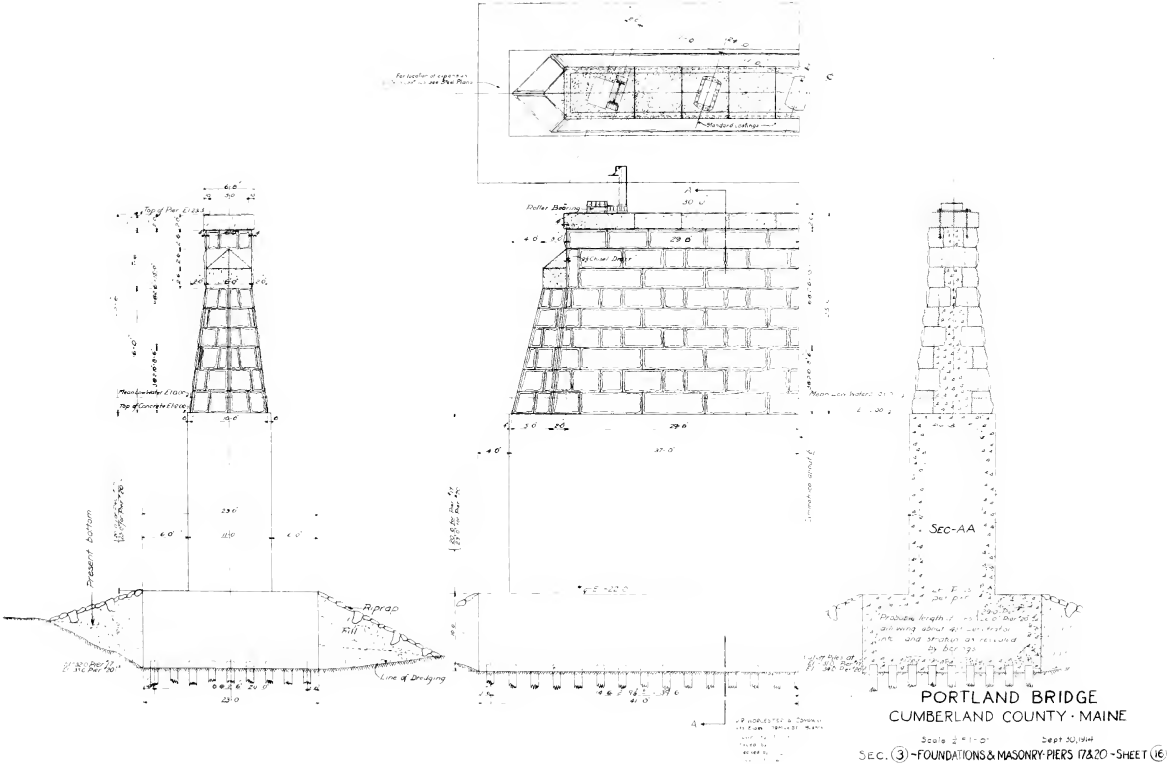

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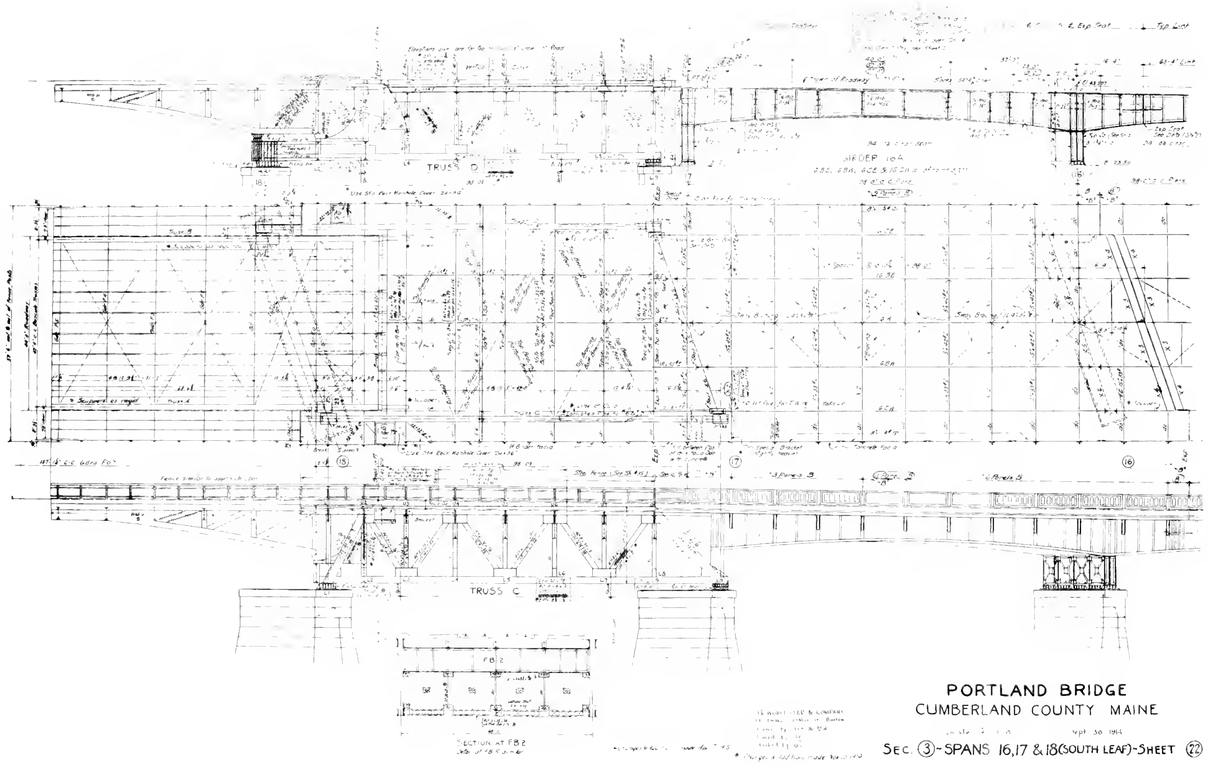

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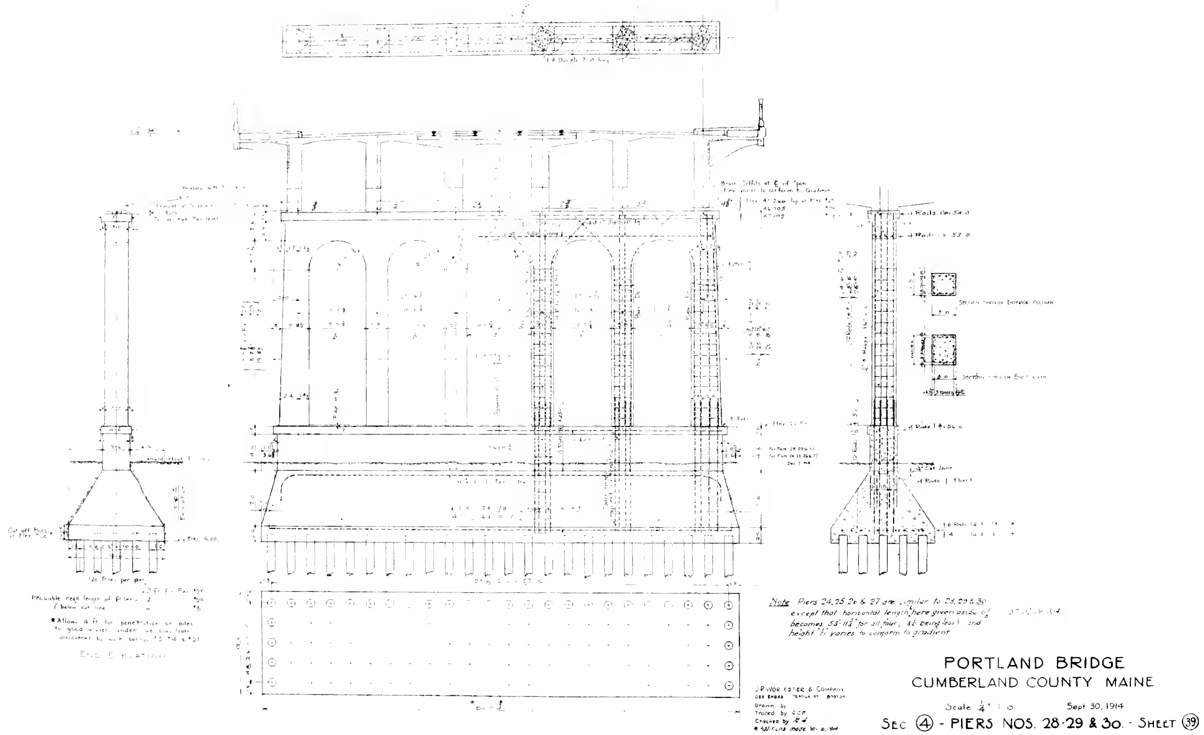

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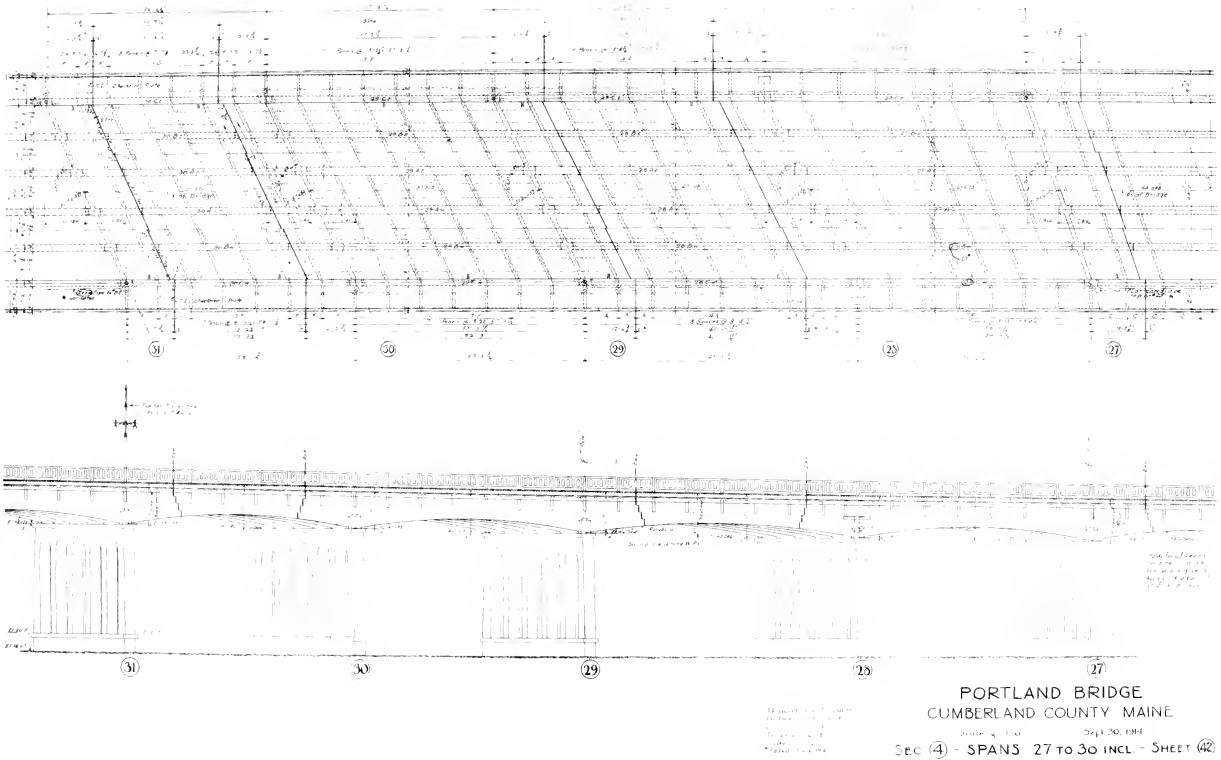

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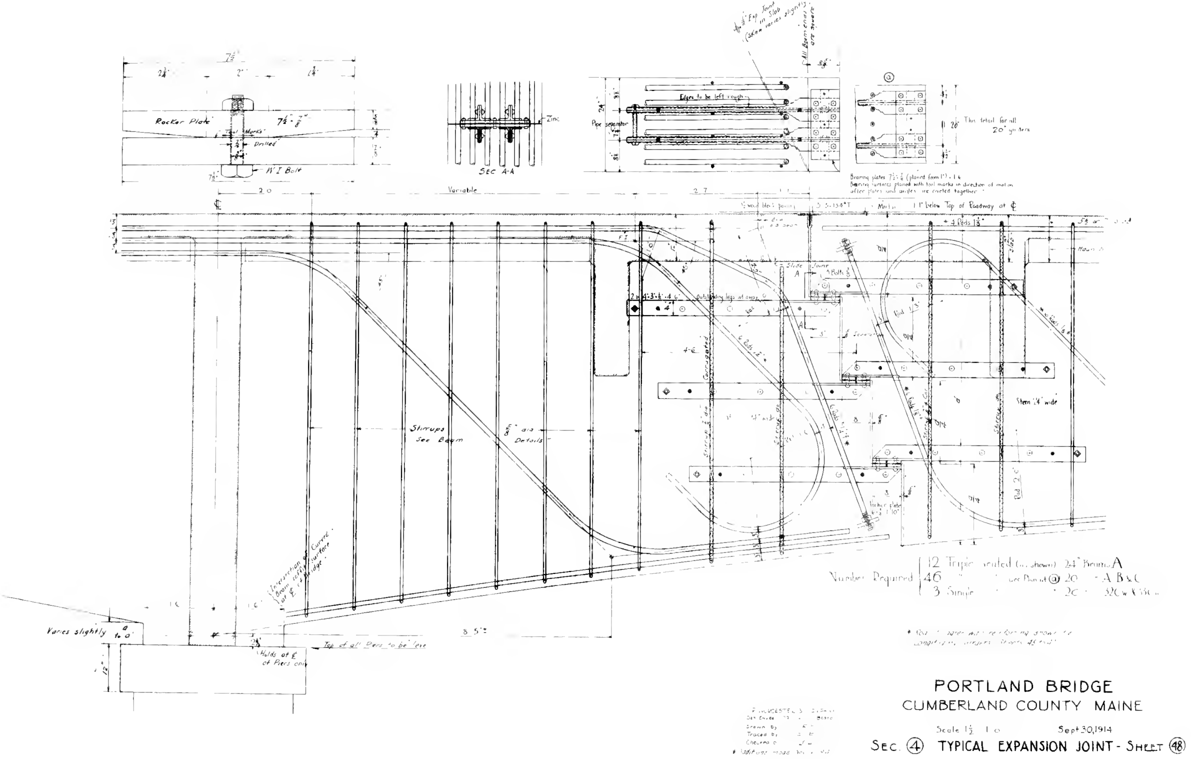

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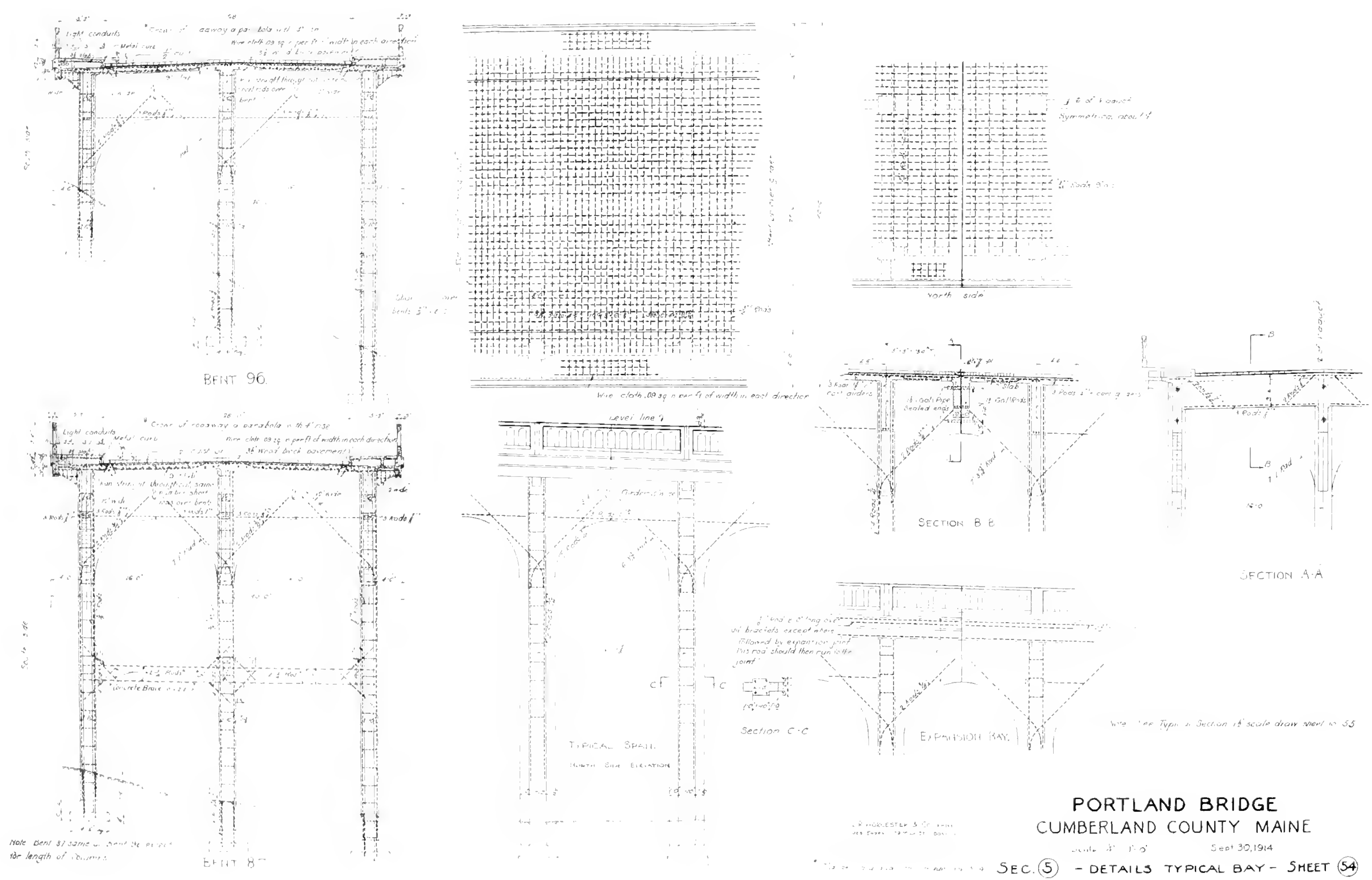
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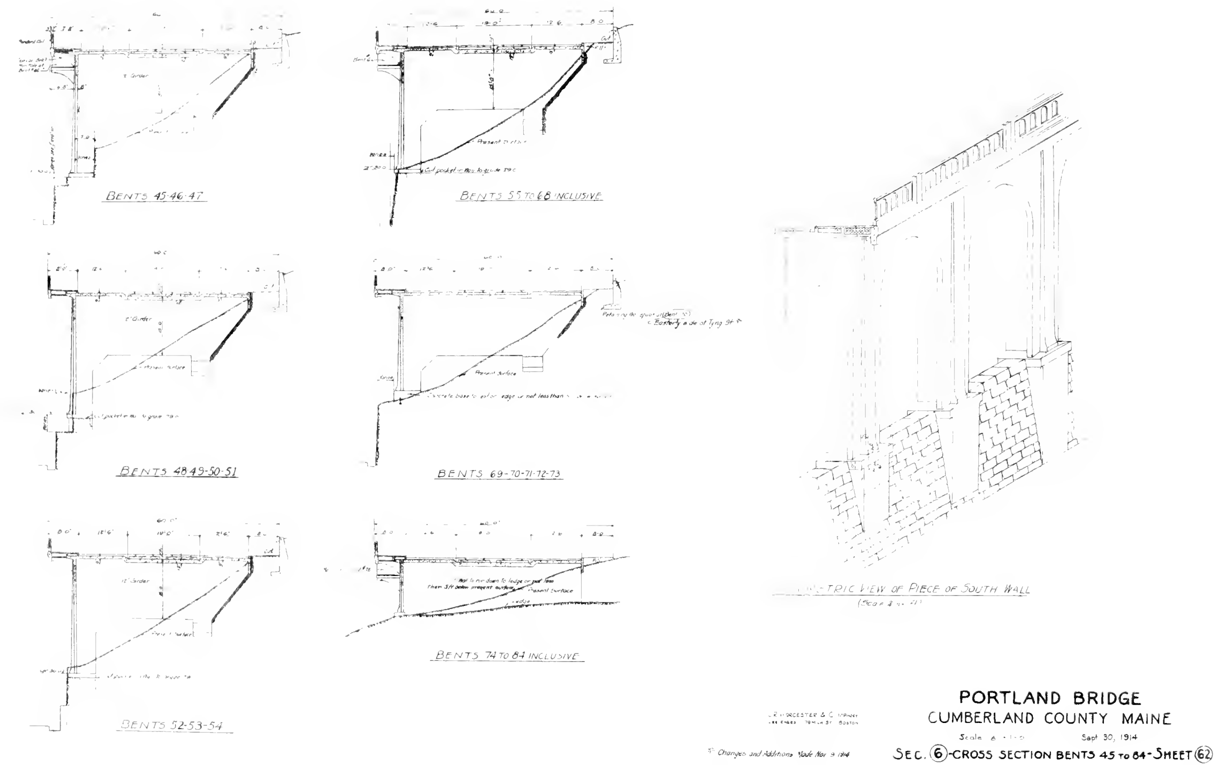
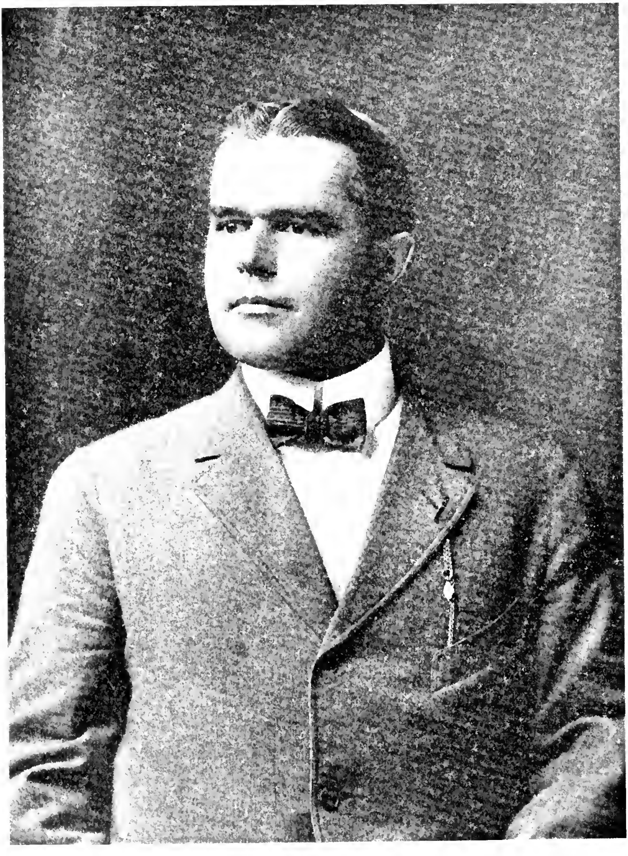




Charles R. Gow,
President, Boston Society of Civil Engineers,
1915–1916.

Vol. III JANUARY, 1916 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PAPERS AND DISCUSSIONS



## THE WATER SUPPLY OF SALEM, MASS.

By William S. Johnson,* Member Boston Society of Civil Engineers.

(Presented October 20, 1915.)

The water works of Salem, like the city itself, have had a long and interesting history. In 1797 a memorial was presented to the General Court showing that the inhabitants of Salem "are poorly supplied with water, and at no time with water that will wash, and that at this time there are many wells that are dry, — that there are within a few miles of that town many ponds and springs from which the inhabitants of said town may be abundantly supplied with good water by means of an aqueduct. . . . Wherefore your petitioners pray that they may be incorporated for the purpose of bringing fresh water from said ponds and springs into the said town of Salem."

As a result of this petition the Salem and Danvers Aqueduct Company was incorporated in 1797, and works were constructed in 1798 to bring water from a reservoir 10 ft. deep and 24 ft. square into the city through a 3-in. log pipe. Water was first supplied in the spring of 1799, and the first dividend was declared in November of that year. This is one of the first water-works systems in this country built for the purpose of supplying water

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before March 10, 1916, for publication in a subsequent number of the Journal.

* Sanitary and Hydraulic Engineer, Boston.

for fire and domestic purposes to the general public. Log pipes were used exclusively until 1834, when the first cast-iron pipe, 6 ins. in diameter, was installed in Essex Street.

For half a century this company continued to supply Salem with water. Frequently there was not enough water for the inhabitants, and it was necessary for the takers to install pumps in order to get water into their houses. Much of the time factories were not allowed to use the water, and there were constant complaints from the citizens. In 1851 a 12-in. main 16 000 ft. in length was constructed to bring water by gravity from Spring Pond in Peabody, one of the present sources of supply of that town. This pond is about 40 ft. above the central portion of Salem.

Eight years later, in 1859, complaints were again made of a shortage of water, and these complaints continued until in 1865 it became necessary to make a connection with Brown Pond in Peabody, another of the present sources of supply of that town. In 1863 it was reported by a citizens' committee that there was not a house where water flowed regularly to the second floor, and that out of 160 or 180 houses having bathtubs in the city, 123 were provided with pumps to raise the water for filling the tubs. Only two fire hydrants were available, and they would not throw streams into a second story or fill a hand engine, and the supply was so limited that a steam fire engine in Boston Street could interrupt the supply for the whole city.

In 1864 the city petitioned the legislature for authority to construct independent works, the supply to be taken from Wenham Lake in Beverly and Wenham. The hearings on this petition were very protracted, and the project was vigorously opposed by the Salem and Danvers Aqueduct Company, the inhabitants of Beverly, and by the mills at Ipswich. Notwithstanding the opposition, the legislature granted the city the right to construct its own works and to take a supply from Wenham Lake.

It was immediately after this action that the Aqueduct Company extended its pipes to Brown Pond, but the city went ahead nevertheless with plans for its own supply, and water commissioners were appointed to carry out the work. A chief engineer was appointed at a salary of $2 000 per year to design the works and have charge of construction, and his estimate of the cost of the entire plant was $497 332.

Work was begun in 1866, and in January, 1868, the work was reported to be not half done and the city had expended $445 736.86. At this time the services of the chief engineer were dispensed with and James P. Kirkwood, of New York, was appointed consulting engineer and Charles H. Swan, chief engineer. From this time the work appears to have progressed more smoothly, and water was finally turned on in December, 1868.

The works built at that time consisted of one Worthington duplex pumping engine with a capacity of 5 000 000 gals. per day, and a pumping station of sufficient size to hold a second unit similar to the first. Water was pumped through a 30-in. cast-iron force main 5 600 ft. long to the open distributing reservoir on Chipman Hill in Beverly. The reservoir is of earth, 400 ft. square, and has a capacity of 20 000 000 gals. The elevation of the reservoir is 115 ft. above the water in Wenham Lake, and about 100 ft. above the general elevation of the built-up section of Salem. A 20-in. cast-iron main was laid from the reservoir to the city, crossing the North River on piles with an inverted siphon beneath the channel. The distributing pipes, about 30½ miles in length, were entirely cement pipes. It is interesting to note that the cast-iron pipe cost $59.77 per ton.

The total cost of the work was $1 100 000, or more than $600 000 in excess of the engineer's estimate. The pumping station, estimated to cost $20 000, cost $103 243, and the reservoir, estimated at $50 000, cost $127 652. Other items were in much the same proportion, except the pump, which was installed for $35 117, somewhat less than the estimate.

The Salem and Danvers Aqueduct Company expired within a short time after the city works were installed. The city was restrained by the courts from interfering with the pipes of the company and was obliged, therefore, to go beneath them, but no redress was obtained by the company for the diversion of the business.

In the beginning Salem sold water to Beverly, but in 1886 that city constructed independent works. By the legislative act authorizing Beverly to do this work, it was provided that Salem should be entitled to two thirds of the water of Wenham Lake and Beverly to one third, and that Beverly should pay to Salem one third of the cost of maintaining the supply.

In 1873 a second pumping unit similar to the first was installed, and in 1890 a new 30-in. cast-iron main was laid from the force main through Danversport to Salem, a distance of $5\frac{3}{4}$ miles. Five years after the works were installed, in 1873, the water commissioners called the attention of the citizens to a shortage of water and advised that application be made to the legislature for permission to take the water of Ipswich River as an additional supply. Nothing was done, however, in the way of additional supply until 1894, when works were constructed for taking water from Longham Brook, a small stream east of Wenham Lake, the water being diverted into the lake by gravity through a 36-in. pipe.

Since this diversion of water from Longham Brook little has been done to the plant until the present year. The lake has been drawn to so low a level on several occasions as to require an auxiliary pumping plant to raise the water so that the regular pumps could draw it, and several times the spring flows have failed to fill the lake. In the meantime the plant has been paying all expenses and turning into the city treasury from $60 000 to $75 000 per year. In 1910, alarmed by the low water in the lake, the authorities of Salem and Beverly engaged the writer to advise them, and the recommendation was made that works be constructed for diverting as much water as was necessary from Ipswich River and for discharging it into the upper end of Wenham Lake. The cities petitioned the Legislature of 1911 for authority to take the water, but much opposition was encountered. The town of Peabody wanted water from the river, the towns on the stream did not wish to have the water diverted, and the mills claimed that by such diversion they would be seriously injured. The Metropolitan water supply was urged by the opposition as the only reasonable supply for all the towns, and in order to get further light the legislature referred the whole matter to the State Board of Health for investigation and report. The board made as thorough an investigation as was possible in the limited time, and reported early in 1912. It found that in the winter and spring a large quantity of water flows off through the Ipswich River which might reasonably be used for supplying Salem, Beverly and Peabody, but found no place which could be used for the storage of this water in large quantities without creating objectionable conditions. The existing reservoirs in these towns might, however, be utilized for this purpose and enough water secured in this way from the Ipswich River to last for several years, — probably not more than ten, — after which it would be necessary to secure a further large additional supply, and the board stated that such a supply can only be obtained from the Metropolitan Water District. It further suggested that the cost of taking water at once from the Metropolitan District might be less in the long run than the cost of using the Ipswich River for ten years and then going to the Metropolitan District.

A further suggestion made by the board which had a very important bearing on the future troubles was that Beverly might purchase Salem's rights in Wenham Lake, thereby securing for that city a source of supply adequate for many years, and that Salem might then enter the Metropolitan District. This proposition was enthusiastically received by the authorities of Beverly and met with immediate and strenuous opposition in Salem. Furthermore, the estimates made by all of the engineers for Salem had indicated that the cost of the Metropolitan supply would be much greater than the cost of a supply from the Ipswich River, especially as the development of the river supply need not be made at once, but could reasonably be made from time to time.

The city of Salem, therefore, insisted on obtaining the right to take water from the Ipswich River, Beverly wished to obtain Wenham Lake, and Peabody objected to being forced into the Metropolitan District. After many hearings the legislature finally passed a bill providing for a special commission of three to investigate and report at the next session. A commission was appointed in June, 1912, consisting of Thomas W. Proctor, John F. McDonald and our honored president, Mr. Charles R. Gow. Mr. Guy Emerson was made engineer for the commission, and Mr. Allen Hazen, consulting engineer.

Now began a contest in which were engaged nearly all of the water-works engineers in this section of the country. Beverly was represented by the late George A. Kimball and R. S. Weston, Peabody by A. W. Cuddeback, Danvers by L. D. Thorpe, the towns in the valley by Metcalf & Eddy, and Salem by the writer, with F. A. Barbour and George W. Fuller as consulting engineers on certain features of the work. Practically every city and town in the valley was represented by counsel and by town officials. The commission held fifteen hearings, and their engineers made quite elaborate independent investigations.

Before the commission was appointed it became evident to the city of Salem that with so many conflicting interests the matter was becoming so complicated that it would be highly desirable to have a thoroughly worked-out plan for the supply of Salem and Beverly for an indefinite time in the future, including the storage reservoirs which must come some time if the Ipswich River supply was to be depended upon, and that everything must be worked out in sufficient detail to meet any possible questions which might arise. Accordingly such plans were prepared, and, as the future doings centered around these plans, and as the result was their final adoption, it may be well to describe them briefly here.

Salem, as already stated, is entitled to two thirds and Beverly to one third of the water in Wenham Lake, supplemented by Longham Brook. Wenham Lake has a watershed of 3.5 sq. miles, an area when full of 250 acres, and a storage capacity to a level 20 ft. below high water of 1 200 000 000 gals. Besides the visible storage, there is available an unknown but certainly large storage in the surrounding soil, which consists chiefly of porous sand and gravel. Longham Brook has a watershed of 3.3 sq. miles, and it is possible to divert all of the water into the lake except at times of very high flow, when some goes by the dam. The estimated yield of Wenham Lake alone, drawing water to 20 ft. below high water, is 3 000 000 gals. per day, and with Longham Brook is 5 000 000 gals. per day.

The consumption of water in Salem in 1912 was 3 767 700 gals. per day, or 82 gals. per capita, and in Beverly 1 830 000 gals. per day, or 91 gals. per capita. The total consumption in the two places, 5 597 000 gals. per day, was beyond the safe yield of the sources of supply, and the rate of increase in the consumption was rapid in both places.

Meters are not in general use in either of the cities, but a careful study of the consumption and of the requirements in the two cities indicated that while the increase might be checked, it would not be possible to reduce the consumption materially by the general use of meters. Manchester, the next town to Beverly, and having somewhat similar conditions, uses 113 gals. per capita per day, or 21 gals. more than Beverly, and in Manchester every service is metered. In Salem, although only 3 per cent. of the services are metered, about 25 per cent. of the total water used passes through these meters, so that the reduction possible by additional meters must be comparatively small. The plans and estimates were all based on a total consumption in 1938 of 11 100 000 gals. per day by the two cities.

In its natural condition the water of Wenham Lake is of excellent quality, being almost colorless and containing a very small quantity of organic matter. The water of Longham Brook is highly colored and contains an excessive quantity of organic matter derived from the swamps through which it passes. The effect of the discharge of this swamp water into Wenham Lake has been very noticeable and the lake water now has a color and is subject to disagreeable tastes and odors.

The only possible sources of supply for Salem and Beverly which would furnish sufficient water to make them worthy of consideration are the Ipswich River and the Metropolitan waterworks. Concerning the quantity and quality of the Metropolitan supply there can be no question. It is certain that a sufficient quantity of good water will always be provided. The only question in regard to this source is as to the expense, and this is a matter of great uncertainty. In determining the probable expense of the Metropolitan supply, it is necessary not only to know the cost of entering the district and the assessments based on present conditions, but it is also necessary to make some estimate of future conditions. The present Metropolitan supply is capable of supplying the district which it now serves for only a limited time, when very expensive additions must be made. Furthermore, the district is expanding all the time, and thus increasing demands for water are being made. Filtration of the supply, or a part of it, will undoubtedly come in the not far distant future. On the other hand, the district will begin to take up its bonds by about 1938, which will reduce the expenses very materially, and the introduction of meters is lessening the consumption and thus increasing the length of time for which the present sources will be sufficient.

Another uncertainty is the possible action of other communities. If Salem alone in this vicinity should enter the district, it would be necessary to pay the entire expense of a pipe line from Spot Pond and other necessary works. If other communities should enter at the same time, the cost to Salem would be much reduced.

Ipswich River, the only other available source, flows within about two miles of Wenham Lake, and is at about the same elevation. Its water could be discharged into the upper end of Wenham Lake by pumping over a low ridge. At a point near Wenham Lake the river drains a watershed of about 95 sq. miles. It is bordered by extensive swamps, and for many miles has but a slight fall, and the water is highly colored, especially at certain seasons of the year.

The seasonal flow of the river is very interesting. In general, the lowest dry weather flows are expected on steep, impervious watersheds, but on the Ipswich, with a very flat watershed, we have unusually low summer flows, due, of course, to the evaporation from the extensive water surfaces presented by the swamps.

In some years it would be practically impossible for several consecutive months to get any water whatever from the river, and it would be necessary, in order to utilize the stream to its fullest extent, to have sufficient storage capacity to store the spring flows for use in the dry months. Wenham Lake would provide a large storage capacity by drawing the water to a low level, but when the consumption becomes greater it will be necessary to provide additional storage. An excellent site for a reservoir was found in Putnamville, where more than 1 500 000-000 gals. could be stored at an elevation somewhat above Wenham Lake, but the water from the Ipswich River would have to be pumped to it. Another site for a reservoir was found in the immediate vicinity, and with these two reservoirs the Ipswich River would be sufficient to supply Salem and Beverly for an indefinite time in the future.

In order to improve the quality of the Ipswich water before discharging it into the lake, it was proposed to pass it through sand filters built in the natural soil on the shore of the lake, these filters being in construction much like intermittent filters for sewage.

Water would be pumped from the Ipswich River in winter and spring to fill Wenham Lake and the storage reservoir. The water pumped into the reservoir would remain there for at least six months, getting the benefit of storage; then in the fall it would be discharged by gravity to the filters on the shore of the lake, thence passing into the lake at the upper end, where it would mingle with the water already there, and pass slowly to the intake at the other end. As a part of the plan, slow sand filters were to be constructed at the pumping stations for the purification of the mixed waters.

This is the plan which Salem presented. Other schemes were submitted by the other parties interested, and the Metropolitan supply for Salem was strongly urged by all except Salem. Mr. Hazen, the commission's consulting engineer, proposed the flooding of the extensive swamps bordering the Ipswich River, thus forming an enormous storage reservoir on that stream sufficient for all of the communities in the vicinity.

The commission finally reported to the legislature in the early part of 1913, recommending substantially the adoption of the plan prepared by Salem, but restricting the quantity of water which might be drawn from the Ipswich River.

The legislature, after still further hearings, passed a bill incorporating the recommendations of the commission and providing that the work be done by a board comprising a chairman, to be appointed by the governor, the director of public works of Salem, and the chairman of the Water Board of Beverly. The time in which water may be drawn from the river is limited by the act to the months from December to May inclusive, no water to be drawn except when the daily flow is 20 000 000 gals. or more, and then only the quantity in excess of that amount and not more than 2 500 000 000 gals. to be drawn in any one season.

Mr. Allen Hazen was appointed engineer of this board, and the execution of the plans has been begun. The works for diverting water from the Ipswich River directly into Wenham Lake are now nearly completed, and it is probable that the reservoir and filters will not be constructed at present.

The future supply of the city having been settled, the people of Salem were beginning to forget the water troubles and turn their attention to grade-crossing elimination and other much-needed improvements, when in June, 1914, came the great fire which wiped out the buildings in an area of 253 acres with a property loss of $15 000 000.

The story of the conflagration is so well known that it is not necessary to repeat it here except so far as it has influenced the further development of the water works. The water-works system did everything that could be expected of it. At the beginning of the fire the 20 000 000-gal. reservoir was about full, and during the fire lost only 500 000 gals. The pumps both operated continuously and there were no breaks in the mains until after the fire was checked, when a 12-in. cement main burst. Although everything worked as it should, the Salem plant failed utterly to give water enough to fight the fire without the assistance of the surrounding towns.

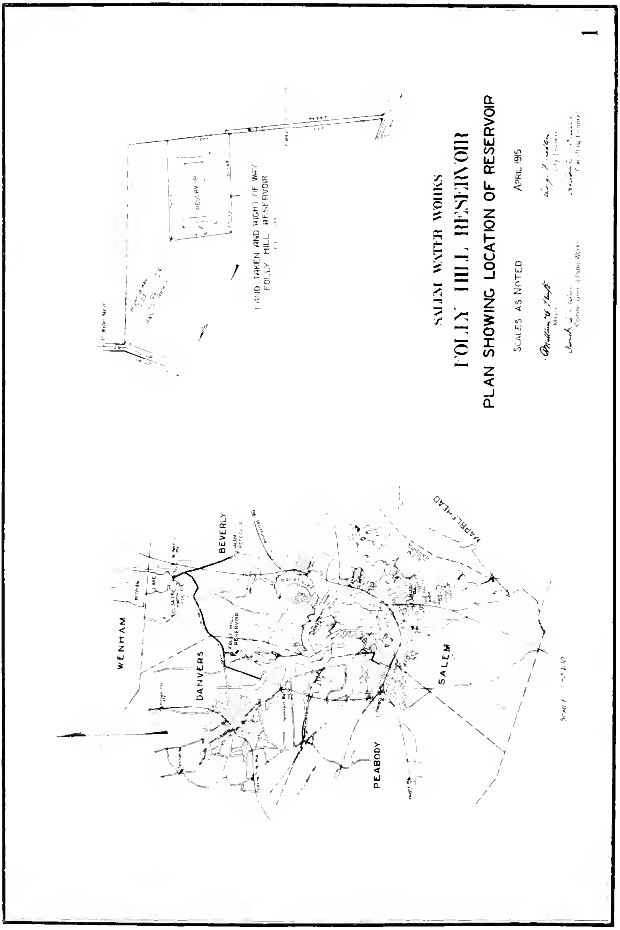
With wise forethought the city authorities had made connections with the pipes of all of the surrounding towns, and during the height of the fire water was being drawn from Peabody, Danvers and Beverly. The connection with Marblehead was opened for but a short time, as the plant is dependent to a large extent on the electric current from the Salem Electric Light Station, which was put out of commission by the fire. All of the surrounding towns have a higher pressure than Salem. The maximum quantity of water used and lost through bleeding services during the fire was at the rate of about 18 000 gals. per min.

The Salem system is a low-pressure system, dependence being placed on steamers for fire protection. The normal pressures in the thickly built-up sections are from 40 to 50 lbs., and on the outskirts in the higher sections the normal pressure is only about 10 lbs. The city is fed from the reservoir by a line of 30-in. pipe $5\frac{3}{4}$ miles long and a 20-in. line 4 miles long, the latter having been in use for nearly fifty years. When the two lines of pipe are delivering 10 000 gals. per min. the pressure in the center of the city is reduced to 28 lbs. The capacity of these lines of pipe had been carefully figured by the city engineer previous to the fire, and it was largely due to his foresight that the connections with the other supplies had been made.

After the fire every one realized the importance of a large quantity of water under good pressure, and immediately the city government took steps to obtain it. This meant something more than a new reservoir and pipe line, for the city still had some 18 miles of the old cement pipes which could not stand an increased pressure, and the old pumps were entirely incapable of pumping against an increased head.

The work of replacing the cement-lined pipe with cast-iron was begun at once, and at the same time the distributing system was improved by providing feeders of large size for the different sections of the city. The work of substituting cast-iron for the cement pipes is now about completed. The use of the old Lowry chuck hydrants, which Salem has clung to for many years, has been discontinued and post hydrants have been used on all new lines.

The increased pressure and volume of water have been obtained by the construction of a new reservoir on Folly Hill in Danvers. The old reservoir was at elev. 145 and the main feeder into the city was a 30-in. pipe $5\frac{3}{4}$ miles in length. The reservoir on Folly Hill will be at elev. 209 and will feed the city through a new 36-in. main $3\frac{1}{4}$ miles long and a part of the old 30-in. main 4 miles long. The capacity of the new reservoir will be 10 000 000 gals., or one half the capacity of the old reservoir.


1
SALEM WATER WORKS
FOLLY HILL RESERVOIR
PLAN SHOWING LOCATION OF RESERVOIR
SCALES AS NOTED
APRIL 1915
LAND TAKEN AND RIGHT OF WAY
FOLLY HILL RESERVOIR
RESERVOIR
WENHAM
DANVERS
BEVERLY
FOLLY HILL RESERVOIR
PEABODY
SALEM
MARBLEHEAD

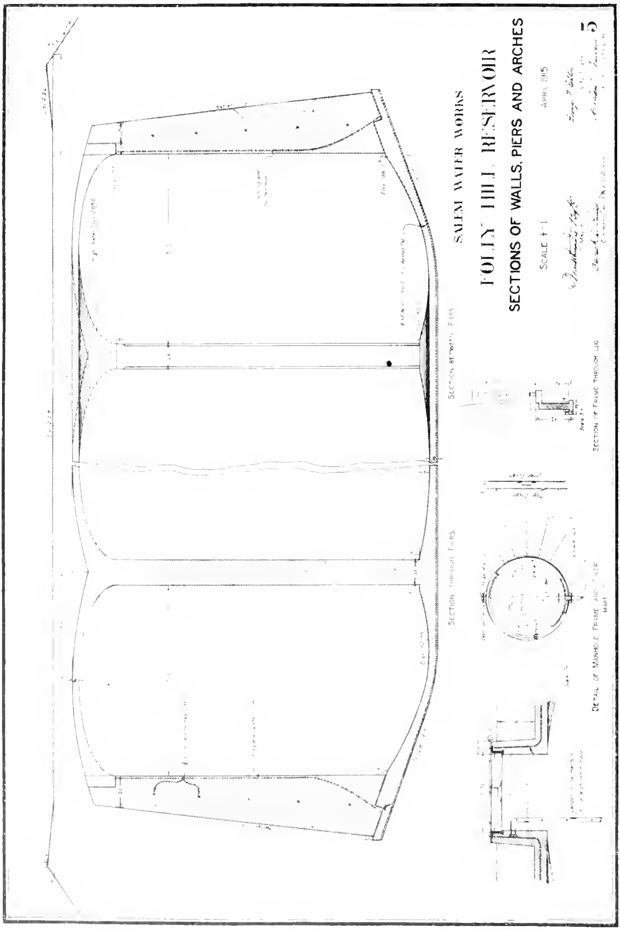
These two pipe lines will be capable of delivering the quantity of water used during the height of the Salem fire with a loss of pressure of about 13 lbs. During ordinary consumption the pressures in the city will be increased from about 50 lbs., as at present, to about 78 lbs.

Folly Hill makes an excellent site for a distributing reservoir, not alone for Salem but also for the surrounding towns, and when the reservoir is completed Salem will be in a position to help the towns which gave such valuable assistance during the fire. When suitable connections are made, this reservoir will give better fire protection for Danvers and Beverly than can be obtained from their own works, and will be of the greatest assistance to Peabody. It could also be used to supply Marblehead by the construction of a comparatively short pipe line.

The highest point on the hill is elev. 205, but the topography is not what might be desired for a reservoir, being a long narrow ridge. It was desirable to get as great an elevation as possible, and various plans were worked out, including circular tanks, but it was finally decided to construct a 10 000 000-gal. rectangular reservoir with a groined arch roof, high water to be at elev. 209 and extreme low water at elev. 182.75. The dimensions of the reservoir, which were determined by the shape of the hill, are 406 ft. by 134 ft.

The covered reservoir was determined on because the water will at some time be filtered, and while it is somewhat uncertain what the effect will be of storing the filtered water in an open reservoir, it is possible, to say the least, that disagreeable growths of organisms may occur unless the water is protected from the light.

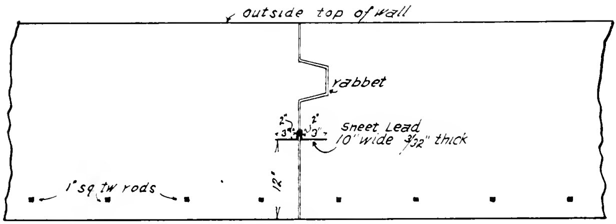
The design of the reservoir is not novel, although in some respects it differs from many of those which have been built. The floor is constructed in two layers, the first layer, 5 ins. in thickness, being flat and reinforced with 6-in. by 6-in. mesh, No. 10 Clinton welded wire. The upper layer is 3 ins. thick midway between the piers and 12 ins. thick at the piers. The floor is brought up at the sides, and ends on a slope of one vertical to three horizontal to about three feet above the elevation


SALEM WATER WORKS
FOLLY HILL RESERVOIR
SECTIONS OF WALLS, PIERS AND ARCHES
APRIL 1915
5
SECTION BETWEEN PIERS
SECTION THROUGH PIERS
SECTION OF FRAME THROUGH LUG
DETAIL OF MANHOLE FRAME AND COVER

of the main floor, and the side walls rest on this. The side walls are 21.5 ft. high to the springing line of the arch. They are 2.5 ft. thick at the top and have a batter on the outside of one in nine, the inside face being vertical. The approximate thickness of the wall at the bottom is 5 ft.

The floor of the reservoir has a slope of 6 ins. from the ends toward the inlet sump at the center.

The walls are reinforced to withstand the pressure of the earth embankment when the reservoir is empty. This reinforcement consists of vertical 1-in. square twisted rods spaced 12 ins. on centers. At the joint between the floor and the wall, and at all other horizontal joints below the springing line of the



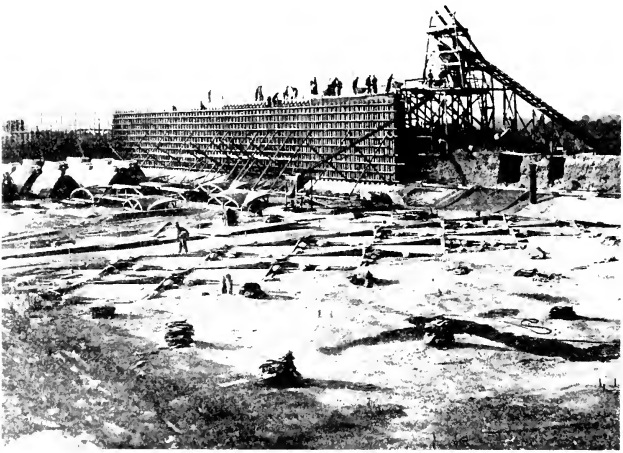

PLAN

VERTICAL JOINT.

arches, there are placed two strips of No. 20 steel, 6 ins. wide, to act as dams and lessen the leakage of water through the joints. The vertical joints are made watertight by a bent strip of sheet lead 10 ins. wide and $\frac{3}{32}$ in. thick. The 161 piers are of plain concrete 2 ft. square with a 2-in. chamfer on the corners and are 24 ft. high. They are spaced 17 ft. on centers and rest on bases 2 ft. 8 ins. square formed by the floor. On these piers rest the elliptical roof arches, which are 6 ins. thick at the crown and have a clear span of 15 ft. and a rise of 3 ft. The roof is depressed 15 ins. over the piers. In it are placed seventeen manholes with double iron covers.

The earth which was excavated will be placed on the top of and around the reservoir. The depth of earth covering on the top above the soffit of the arches will be 18 ins. The embankment will be carried out to a point 7 ft. 3 ins. from the inside of the reservoir walls and will then have a slope of one and one-half horizontal to one vertical.

On the easterly side of the reservoir is a chamber built on the wall to provide for the overflow. In the bottom of this chamber is a 16-in. pipe leading to a tile drain which discharges at the bottom of the hill.



The gatehouse is to be of hollow tile construction with a surface of plaster and a red tile roof. It will contain, besides the gate stands, the registering apparatus for the 36-in. meter which is to be installed just beyond the inlet to the reservoir.

The earth excavation for the reservoir was done by day work in order to provide employment for some of the many men thrown out of work by the fire. About 30 000 cu. yds. of very hard material were removed at a cost of $22 000, or about 73 cents per cu. yd. The earth removed was placed in the embankments as far as possible and the remaining material was placed in spoil-banks. This is a wasteful method of doing the work, as it means handling much of the material twice, but it was considered advisable not to have the city workmen and the contractors' workmen on the job at the same time, one reason being that the city laborers were paid at a rate of about 35 cents per hour, while the contractor's men receive about 20 cents.

The contractors for the work are A. G. Tomasello & Son, and they receive the following prices:

| Item. | Estimated Quantity. | Unit Price. |
|---|---|---|
| Earth excavation. | 1 000 cubic yards. | $1.00 |
| Earth fill. | 25 000 cubic yards. | .35 |
| Concrete in piers and arches. | 2 200 cubic yards. | 8.45 |
| Concrete in floor. | 1 850 cubic yards. | 7.00 |
| All other concrete. | 3 300 cubic yards. | 6.30 |
| Reinforcing steel. | 53 tons. | 75.00 |
| Gatehouse. | Lump sum. | 1 400.00 |
| Fertilizing and seeding. | 3 acres. | 100.00 |
| Appurtenances. | Lump sum. | 700.00 |

The total price, based on the estimated quantities, is $68 455, not including the work done by the city, which amounted to about $22 000.

The 36-in. pipe line has not yet been constructed. It will enter the city by a new route, crossing the Danvers and North rivers.

What the effect of the increased pressure on plumbing will be is somewhat uncertain. Salem has been provided with a water supply since 1797, and while there may be no plumbing which was installed at that time, some of it must have been put in shortly after. Some trouble is anticipated. Furthermore, while all of the cement-lined pipe, so far as known, will have been replaced before the higher pressure is turned on, it is suspected that there may be short lengths still remaining which are unknown, as the records were not always so well and systematically kept as they are now.

Much consideration was given to the type of pumping plant to be installed. Two 10 000 000-gal. units were desired, and it was desirable to use the old pumping station if possible.

The pumps must be able to draw at least 25 ft. from the lake, which means that they must set very low in the station. When the old pumps were installed much difficulty was experienced with the foundations and with the construction of the pump well in the station, on account of water and quicksand.

The best bid received was one of $30 280 from the Power Equipment Company for DeLaval centrifugal pumps and steam turbines, the guaranteed duty being 140 000 000 ft.-lbs. per 1 000 lbs. of steam. The best proposition for reciprocating engines was from the International Steam Pump Company for Snow horizontal cross-compound steam pumps, the guaranteed duty being 165 000 000 ft.-lbs. and the cost $41 100 above the foundations.

Comparatively little is known regarding the depreciation or repairs of such a plant as that offered by the Power Equipment Company, but after allowing liberally for these items and considering the cost of the foundations, which were to be furnished by the city, it was decided to accept the bid for the turbo-centrifugal plant.

Each unit will consist of two 16-in. centrifugal pumps in series, operated by a 460 horse-power steam turbine. The condenser will be of the water-works type placed in the suction, and it is expected that a vacuum of 29 ins. will be maintained under ordinary conditions. Steam is to be furnished from the present boiler plant, but Foster superheaters are to be installed.

There are already three intakes in the lake, but none of them is suitable for the new plant, so a new 36-in. intake is to be installed with an intake chamber and gatehouse. Arrangements will be provided so that water may be drawn at either of two levels, the lower opening being 25 ft. below high water.

The contract for this work has been awarded to the Bay State Dredging Company of Boston for $13 800. The total expense of all of the improvements to the system, exclusive of the work on the Ipswich River supply, will be $500 000.

## DISCUSSION.

Mr. Charles R. Gow.* Referring to the work of the special commission appointed by the governor in 1912 to investigate the whole question of a water supply for Salem and some other municipalities, as mentioned by Mr. Johnson, and on which I had, as he has stated, the honor to serve, I wish by way of discussion to add a few words to what has been said.

I am particularly impressed by one fact as I view the matter in retrospect, and that is the continued adequacy of the old supply after a lapse of more than three years, in spite of the conviction of the commission and all other parties concerned at the time that the cities and towns considered were in imminent danger of a water famine and that immediate relief was imperative. As engineers, we, of course, readily understand the reason for this seeming anomaly, viz., the difference between a safe and a normal yield of a given supply. It is quite difficult for the average lay mind to grasp this distinction, and it is unfortunate for us that such is the case. The fact that the past few years have brought a return of normal yields in the ponds and streams after a series of extremely dry seasons will in all probability not be appreciated by the general public to such an extent as to eliminate entirely the impression that the engineers erred in judgment. Happily, now, it appears that the danger of shortage is at an end and the new supply will soon be made available.

One of the several interesting questions presented for the consideration of the commission was that submitted by the city of Beverly, whose representatives maintained that, because Wenham Lake was situated partially within the geographical limits of that city while none of it bordered upon any part of Salem, the latter municipality should be compelled by the Commonwealth, now that the supply was inadequate for both cities, to surrender all of its rights and interest in this supply to the city of Beverly. Here, then, was a city which had enjoyed water privileges in one of the Commonwealth's great ponds for nearly fifty years under a grant of the legislature; had invested large sums of money in plant, equipment and pipe lines in addi-

* The Charles R. Gow Co., General Contractors, Boston.

tion to that for improvement of the supply itself; had first, by direction of the Commonwealth, supplied water for the purposes of Beverly and later divided the supply with that city under a joint arrangement, and now it was urged that it be compelled to abandon all of this investment and seek an entirely new supply elsewhere.

There seemed to be no precedent available as a guide to the commission, and while it was apparent that the Commonwealth which granted the original rights to Salem presumably could revoke them at any time, it was extremely doubtful in our minds that such action would be taken without a provision for adequate compensation. In the event of the payment by the city of Beverly of any sum that would reasonably reimburse the city of Salem for its sacrifice, there would result a greater cost to the first-named city than would seem to come from continued joint action between the two municipalities. The suggestion was, therefore, rejected by the commission.

Careful consideration was also given to a proposed plan for including Salem and possibly some other towns and cities in the neighborhood within the group to be supplied from the Metropolitan water system. There appeared to the commission to be at least two serious objections to this proposal. First, from the standpoint of the municipalities themselves, it was found to entail the greatest expense of all the suggested measures of relief, and the proposal, therefore, met with bitter opposition from the inhabitants thereof. No municipality located within the geographical limits of the Metropolitan District had ever been compelled against its wishes to join the system, and there seemed all the more reason why places as remote from the district as Salem should not be forced to assume the financial and other burdens entailed by membership in the Metropolitan water system. Second, from the standpoint of the Commonwealth, and especially of the Metropolitan District, it seemed to the commission to be questionable whether it would be wise to extend the limits of the system to points as remote as Salem and the other municipalities. It would bring about a much earlier exhaustion of the existing Metropolitan supply, with the consequent necessity of taking new sources from other parts of the state wherever they might be available. Furthermore, there was a sufficient and satisfactory supply close at hand for these cities and towns, and it was, therefore, determined to recommend the development of the Ipswich River waters for the purpose.

For the relief of the cities of Salem and Beverly it was recommended that the river water be pumped to a new storage reservoir, utilizing the flood flows in the river during the winter months, in order that the Wenham Lake supply might be amplified during the summer months of shortage. The commission was impressed with the storage feature in connection with its conclusions because of the high color of the river water and the consequent difficulty of removing it by means of slow sand filtration. It was recognized as practically conclusive that mechanical methods of filtering would successfully meet the color difficulty, and there was much cumulative evidence presented by eminent authorities on the subject of filtration tending to prove to the commission that the mechanical method was, all things considered, the more desirable method for adoption, in this case. The commission was aware, however, of the opposition on the part of the State Board of Health to the use of mechanical methods of filtration wherever such use could be avoided, and for this reason it was deemed preferable to adhere to practices which would not conflict with a settled policy of a responsible state department such as our Board of Health.

The recommendations of the commission as reported to the legislature were finally adopted and enacted into law with the exception of the provision for the storage reservoir, which was deemed to be unnecessary for the present. Since that time additional legislation has been secured altering some features, especially that relating to the point of taking the water from the river and of conducting it to Wenham Lake.

Referring to the construction work on the new high-service reservoir which Mr. Johnson has described and illustrated, and which many of us had the pleasure of inspecting to-day, I wish to congratulate him and his contractors upon the excellent quality of the workmanship attained. It has fallen to my lot to construct or supervise the construction of much work of a similar character, and I will say without reservation that I consider this work the equal in appearance and general excellence of workmanship of any I have seen. This of course reflects great credit on the engineers and officials who have supervised the work, but at least equal praise is due the contractors, without whose ability and superintendence such results could not have been obtained.

I wish to comment especially upon the small amount of plant used by this contractor in carrying on the work, and the apparent efficiency and economy of the methods which he has applied. I have long realized the tendency to over-plant jobs of this kind, and was, therefore, interested to note the effective results being obtained in this instance by comparatively simple methods. The large amount of form work required for this class of work in comparison with the amount of concrete used makes possible the placing of only moderate quantities of the latter material in a given day. The overhead cost of elaborate handling devices may, therefore, more than offset the apparent saving in labor.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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# MEMORANDA ON CERTAIN EARLY TYPES OF TURBINES OR OTHER WATER WHEELS.

By Charles W. Sherman,* Member Boston Society of Civil Engineers.

*Rose Wheel.* (Fig. 1.) This is a downward flow wheel consisting of a cast-iron runner, as shown in the photograph, with vanes flat or nearly so, supplied with water through a cast-iron nozzle connected to the end of a rectangular wooden flume or conduit. The nozzle is divided into two parts by a vane or guide and covers somewhat less than half the upper surface of the wheel. The wheel is, therefore, something between an impulse wheel and a vertical flow turbine.

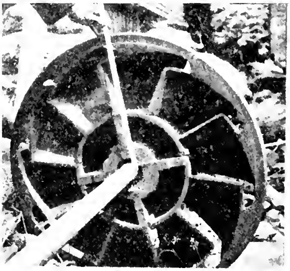
*Blake Wheel.* (Fig. 2.) This is an inward flow turbine of a primitive type.

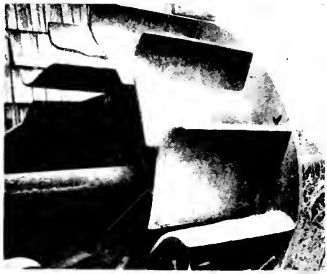
*Chase Wheel.* (Fig. 3.) The photograph shows very imperfectly a view of a 30-in. turbine made by the Chase Turbine Mfg. Co., of Orange, Mass. This wheel was supplied through a rectangular wooden conduit connecting with a cast-iron section and discharging into the side of the wheel case. In the cast-iron section is a butterfly valve by which regulation was accomplished. The spaces between the buckets were small, and another wheel of this type, which had been removed, showed the spaces to be plugged up to considerable extent with stones.

*Hunt Turbine.* (Fig. 5.) The wheel illustrated was manu-

* Of Metcalf & Eddy, Consulting Engineers, Boston.

factured by Hunt, Waite & Flint, Orange, Mass., and the name-plate indicates that it was patented in 1869. This is an inward and downward flow wheel, and, as is shown by the photograph, the spaces between the buckets are very small. The wheel has been whitewashed since its removal. Careful inspection of the picture will disclose the presence of a large number of sticks and





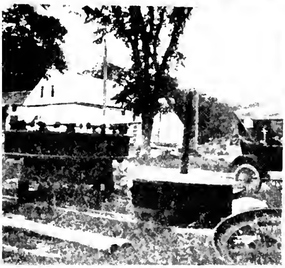


FIG. 1. ROSE WHEEL.

FIG. 2. BLAKE WHEEL.

FIG. 4. STEVENS WHEEL AND CASE.

FIG. 5. HUNT WHEEL (Old Pattern).

stones which, in considerable measure, clog up the spaces between the buckets.

*Stevens Wheel.* (Fig. 4.) The photograph shows somewhat imperfectly the features of the gates and of the runner of a turbine made by G. C. & J. F. Stevens, Ayer, Mass., patented in 1872, and at one time rather popular in northern Massachusetts and southern New Hampshire. This is an inward flow wheel with vanes rather sharply curved.

FIG. 3. CHASE WHEEL.

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# JOINT MORTAR EXPOSED TO TIDAL CURRENTS.

By John L. Howard,* Member Boston Society of Civil Engineers.

In building sea walls of coursed granite masonry laid in mortar and exposed to the action of tidal currents, where the bottom course is not more than one foot above mean low water, much difficulty is often encountered in holding the mortar in the joints long enough to give it time to set, as the action of the tides rising and falling on the fresh mortar will pull it out of place. It does not matter how rich a mixture is used, whether 1 : 1 or neat cement, it is impossible to keep the mortar in place till it hardens.

On one piece of construction under the writer's supervision this difficulty was successfully overcome by mixing plaster of Paris with the mortar in the proportion of one part of plaster of Paris to three parts of 1 : 1 mortar. This mixture hardened within five minutes, and no further trouble was experienced from the mortar in the joints failing to set in place, and the pointing of the joints in which this mixture had been used was entirely satisfactory.

* Assistant Engineer, Directors of the Port of Boston.

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# DISCUSSION OF SOME SPECIAL METHODS OF REINFORCED CONCRETE DESIGN.

By J. R. Worcester, H. B. Andrews and M. J. Lorente.

Mr. J. R. Worcester* (*by letter*). — It is unfortunate that this paper, which embodies so much information in tabular and diagrammatic form, should be impaired by the condensation of the descriptive matter to such an extent as to be almost unintelligible. The confusion is partly due to inexcusable omissions, such as the explanation of the notation used in the first three equations, and partly to the absence of a clear explanation of the successive steps in the reasoning. For instance, in describing the method of obtaining the moment of resistance of the T-beam, it should be noted that the moments of the subtracted areas are those about the neutral axis of the section as a whole and not about their individual axes. It should further be explained that the whole paper is limited in application to beams with balanced reinforcement, that is, with just enough steel to produce simultaneously the desired stresses in both concrete and steel. As all designers know, this condition is comparatively rare. Of course, by having enough tables to cover a sufficiently wide variation between compressive and tensile stresses it may be possible to find a beam somewhere near the desired section, but this appears to be a backhanded and cumbersome method to adopt.

*J. R. Worcester & Co., Consulting Engineers, Boston.

In the design of rectangular beams reinforced in compression, the method of Messrs. Clifford and Mangold is much more useful and concise. Their diagrams and tables are easy to understand and to use, and should prove very valuable to designers.

Mr. H. B. Andrews* (*by letter*). — The need of standard methods for designing reinforced concrete members has long been perceived, and it was with the view of establishing recognized standards that committees were appointed in 1903 and 1904 by several engineering societies. The 1913 report was a culmination of their investigation, and this report recommended formulæ covering the ordinary features of design. This report also included the ground covered by Mr. Lorente in his paper. While Mr. Lorente's paper is very interesting and apparently worked out on a reasonable basis, the final results attained are not so very different from recommendations of the Joint Committee.

It would seem that the report made by this committee, composed of the best engineers of this country, should be sustained unless there was some well-grounded reason for taking exceptions to it.

There is this, however, to say about the Joint Committee's report. It is not in practical shape for use by the designer, and will not be until standard sections are worked out and tabulated so that the designer can obtain his concrete sections as easily as he can steel sections from a structural steel handbook.

I have endeavored to work out a practical and ready method of using the recommendations of the Joint Committee in some diagrams and tables which I have not published, but have some blue-prints of, which I would be glad to show to members of the Society.

There is a limit to the sectional area of steel that can be used in a 1 : 2 : 4 concrete; $p$ must not be greater than .89 per cent. for rectangular beams, and not greater than 2.13 per cent. of the rectangular section of T-beams. The limiting factor in the first case is the allowable compressive stress in the concrete, which is 715 lbs. per sq. in., and in the second case, the same al-

* Chief Engineer, Simpson Bros. Corporation, Boston.

lowable compression in the bottom of continuous beams at supports plus the compression in one half of the reinforcing rods lapped sufficiently with the rods of adjacent beam to develop their full working compressive strength.

It seems to me that this is the only place where compression steel can be used economically or practically, and it is not necessary to use it here, as the concrete can be increased in section by haunching the beam so that the full compression can be resisted by it alone.

Concrete is a flexible material, and may be subject to many variations in design. It is also subject to mechanical difficulties of handling which may not be readily apparent in the design. Steel is not as economical in compression as is concrete, and the richer the concrete, the more economical it is. Therefore it is not desirable to reinforce with steel the upper portion of a concrete beam to obtain additional strength. In the first place, with the beam loaded up with 2.13 per cent. of steel, you have nearly all the steel you can conveniently place concrete around and still properly spade it, without any additional compression and tension steel. In the second place, a 1 : 2 : 4 concrete is general up to the limit allowable for shear or diagonal tension with the maximum of 2.13 per cent. of tension steel. In the third place, if it is absolutely necessary to get additional strength with a limited section, use a richer concrete in the beams and in the necessary width of flange, for which the maximum value of $P$ may be assumed at 2.70 per cent. for a 1 : $1\frac{1}{2}$ : 3 concrete, or 3.20 per cent. for a 1 : 1 : 2 concrete. You will find that this will give all the steel you can mechanically take care of. Fourth, provided you have a thin slab combined with a deep beam or girder, it is often desirable to thicken up the slab at the intersection with beams to obtain larger compression area of concrete.

Without any criticism of Mr. Lorente's able and interesting paper I wish to emphasize my personal views that it is not necessary or wise at this time to put out formulæ dissenting from or varying slightly from the Joint Committee's recommendations, and thus further muddling the brains of the engineer who has occasion to use reinforced concrete sections in his every-day work and has not the time to work out intricate formulæ or reconcile variations in different theories, and that there is no necessity for compressive steel in the upper side of concrete beams.

While figures do not lie, and the results obtained are always the same, using the same figures in the same way, nevertheless the actual results obtained in building concrete members will vary to a certain extent, as there is an allowable variation in strength of concrete between prescribed limits. There is a variation in modulus of elasticity of concrete, a slight variation in the moment arm, which for convenience is assumed generally as $\frac{7}{8}$ *d*, so that in considering formulæ which only technically differ, we are actually putting ourselves in the same position as the man who wishes to obtain a certain measurement approximately, and paces it off, and then measures the last few inches with a tape so that it may be accurate.

Mr. M. J. Lorente (*by letter*). — The author wishes to join Mr. J. R. Worcester in his commendation of Messrs. Clifford and Mangold's method of dealing with beams with steel in compression. He would like to point out, however, that there is no fair comparison between their and his own methods.

Messrs. Clifford and Mangold's method is useful in reviewing a beam, i. e., in finding the stresses in a given section, with a given amount of steel. But for designing a beam, i. e., finding the amount of steel necessary in a section, their method is of the hit-or-miss variety, whereas the author's will give the exact amount at the first trial and with little trouble.

Considering that such eminent engineers as Messrs. Worcester and Andrews have entirely misunderstood the paper, perhaps there is some truth in Mr. Worcester's statement that the paper is " almost unintelligible." The author, nevertheless, is of the opinion that any paper is unintelligible, no matter how much intelligence the writer may have put into its writing, if the reader refuses to use his own intelligence in the reading of it.

The omissions which Mr. Worcester complains of were deliberately made because the author bore in mind the fact that he was not addressing a class at a technical school but a society of civil engineers. The formulæ whose notation was not explained are of such an extremely elementary nature that no engineer worthy of the name should fail to recognize them at first sight.

Mr. Worcester seems to be under the impression that the location of the neutral axis of a beam section is fixed. Now, the location of the neutral axis of a beam, being absolutely independent of the shape or material of the section, can be anywhere. If we make $\frac{f_s}{n} = f_c$, the neutral axis will be equidistant from the top of the beam and the center of the steel. If $\frac{f_s}{n}$ be considerably larger than $f_c$, the neutral axis will be near the top of the beam. Again, if $\frac{f_s}{n}$ be considerably smaller than $f_c$, the neutral axis will be quite close to the steel. In the section in question, the stress in the concrete of the imaginary areas subtracted is the same as that in the concrete at the bottom of the slab in the T-beam, and, as the stress in the steel is the same for both the T and the sections subtracted, the neutral axis of the latter must of necessity coincide with the neutral axis of the former, so that, taking them separately, the neutral axis of the whole is the neutral axis of each part. That the two coincide is not a mere caprice of the author but a mathematical eventuality without which the method would be an utter impossibility.

Mr. Worcester's statement that "the whole paper is limited in application to beams with balanced reinforcement, that is, with just enough steel to produce simultaneously the desired stresses in both concrete and steel" is absolutely unwarranted, except by a complete failure to grasp the author's method. Supposing we had a bending moment of 2 188 000 in.-lbs. and that considerations of shear and head room limited the size of the beam to a width of 14 in. and an effective depth of 25 in. Suppose further that the thickness of the slab be 6 in. By the author's method, we would find that the area of steel required would be 5.47 sq. in. Even if we could get a combination of bars that would give us the required steel area, the beam would not be balanced because the width of T required would be only 30 in., yet we could, if other considerations permitted it, use at least 60 in., for the slab is 6 in. thick. Such a beam is far from being a balanced beam, yet it is a perfectly practical one, similar to thousands that are being designed daily, and it can be obtained by following the author's method. The fact of the matter is that the author's method is not limited at all and may be applied to any T-beam whatsoever.

Mr. Worcester again has missed the point in regard to beams with steel in compression. Messrs. Clifford and Mangold's method may be "much more useful and concise," but neither could be replaced by the other. As already explained, the author's method will give a design at the first trial. The other method will not, unless by mere chance, for that method is for reviewing, not for designing, a beam.

Mr. Andrews unnecessarily takes up the cudgels in favor of the Joint Committee, for the author did not make any attack upon them. In fact, all his assumptions have been sanctioned by the Committee. So that, not only are the results obtained by the author's method "not so very different from the recommendations of the Committee," but they are bound to be exactly alike.

What the author has done is to use his mathematics in a different way, so as to facilitate the design, for, as Mr. Andrews says, the Joint Committee's report "is not in practical shape for use by the designer."

The author fully sympathizes with Mr. Andrews in his wish to standardize concrete beams, but, should Mr. Andrews undertake the task and live long enough to accomplish it, he would be sure to break the record for longevity. For, whereas steel beams are limited in shape and stresses, concrete beams are susceptible, within practical limits, of endless changes.

As to steel in the compression side of a beam, the author again disagrees with Mr. Andrews. Steel may not be as economical as concrete, but economy is not always the ruling factor in design. Other considerations far more important very often compel the use of steel in compression. Thus the author could point out to Mr. Andrews hundreds of beams, built in Boston and neighborhood, from the designs of very competent engineers and with the approval of men of eminence in the profession, where the use of steel in compression could not have been avoided.

The use of haunches in beams can seldom be resorted to, for, as a rule, the architect objects to them. Besides, it is doubtful whether the saving in steel would compensate for the extra expense in complicated form work and in detailing.

Apart altogether from the fact that the author did not say or advocate anything in his paper against the Joint Committee, he would like to point out to Mr. Andrews that the Joint Committee is just as fallible as all human institutions are liable to be. He should remember that the Committee is not formed by the only eminent engineers on earth but by only an extremely small number of them. And he should not forget that some of the members of the original committee, just as eminent as those in the present body, very forcibly dissented in a minority report from the findings of their colleagues. So that the report is the expression of opinion of a very limited number of engineers, and it is rather a pity that men like Mr. Andrews should attribute to that report a finality to which the Committee itself laid no claim.

The report of the Joint Committee is only a "progress report" which has already undergone some modifications and will, no doubt, suffer a good many more in years to come. And it could not be otherwise, for the reports are founded on the theories, experiments and works of a host of toilers who are constantly striving for something better. The report is, in fact, a record of the work done in the field of reinforced concrete, and even as a record it is considerably behind date, as there is still no mention of flat slabs in it. Would Mr. Andrews advocate that no such slabs be built and that no investigations be made, simply because the Joint Committee say nothing about them?

If independent thinkers and observers should cease their labors because the Joint Committee has issued a report, then the Committee would become a victim to paralysis from want of something to do, and *ipse facto* would cease to exist.

The author's opinion is that we all should do our share in the advancement of engineering science, hoping that the Joint Committee will some day recognize our labors before its usefulness has passed.

## MEMOIRS OF DECEASED MEMBERS.

### THEODORE LOUIS KEPPLER.*

The subject of this sketch was probably one of the least known to the membership of the Boston Society of Civil Engineers, and one of the best loved of men by the few who came in contact with him. His extremely courteous, hospitable and modest manner instantly charmed not only those whom he met casually, but also his hundreds of employees. Such a man was Theodore Louis Keppler, who was born at Stuttgart, Württemberg, Germany, November 28, 1847.

His schooling was limited, for, at the age of sixteen, he went to sea, and during the next few years he traveled over a considerable portion of the world, at one time acting as mate of a vessel. With the tide setting toward America just after the Civil War, he landed in Boston in 1867, and, walking up a street near the wharf at which he had just landed, was so insistent in being put to work by almost the first merchant he accosted, that he was promptly hired, and remained for some months at the occupation, now passed into oblivion, of painting scenery on window screens, at which Mr. Keppler rather excelled. But tiring of this kind of work he soon found employment in the Union Sugar Refinery at Liberty Square, in Charlestown. He was here from 1868 to 1871, when he went to the Standard Sugar Refinery at South Boston on Granite Street, and remained there up to the day of his death.

His long career in one establishment rather contradicted the idea that a man must needs shift employers to avoid stagnation. Mr. Keppler rose by successive steps to the position of assistant superintendent, which position he held up to 1895, when, on the death of Mr. John H. Webster, a member of the Boston Society of Civil Engineers, he was made superintendent,

* Memoir prepared by Frederic I. Winslow.

holding this position at the time of his death, so that he was in the employ of the Standard Sugar Refinery for forty-four years.

Mr. Keppler became an associate member of the Boston Society of Civil Engineers February 16, 1910, and although rarely seen at the meetings of the Society he appreciated them highly, and on one occasion entertained the members at the refinery in a manner which lingered long in the minds of those who were present. He was a man of almost no vacations, and was at the works every day without exception for many years. He was the soul of geniality, extremely generous-hearted, and although a very busy man, could always find time to be helpful to others. The immediate cause of his death, which occurred at his home in Brookline on May 24, 1915, was pneumonia. He leaves a widow, a brother and a sister, the two latter residing in Germany.

Mr. Keppler was a member of the Algonquin Club, the Merchants Club, the Boston Chamber of Commerce, the Engineers Club, Order of Odd Fellows, the Maugus Club of Wellesley, the Hull Yacht Club, Deutsche Gesellschaft and a number of philanthropic societies.

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## LEVI GOWEN HAWKES.*

Levi Gowen Hawkes, one of the older members of this Society, was stricken with paralysis while at work in his office in October, 1914, and died on the 8th of November of the same year.

Mr. Hawkes was born in Saugus, Mass., April 14, 1851. He was the son of Louis P. and Mary A. (Gowen) Hawkes, the oldest of seven children, and a direct descendant of Adam Hawkes, one of the first settlers of the town. His early studies were in the local public schools. At fourteen he attended a private school in Lynn and at sixteen he entered the Friends' Boarding School at Providence, R. I., where he remained two years, making a record as a keen and painstaking student. Later he studied civil engineering in Boston, under Professor

* Memoir prepared by James E. Stone, Theodore P. Perkins and Edward P. Adams.

Watson, and thereafter was engaged in engineering work for the Boston & Providence Railroad Company and other steam and street railway companies in Massachusetts, Rhode Island, Connecticut and New Jersey.

Mr. Hawkes became a member of the Society December 19, 1888, and made his home in Boston for a time, working on various engineering matters. Afterward he opened an office in his native town and there remained, building up a reputation as a competent engineer and surveyor, and establishing himself as an authority on the lines and bounds of a large number of estates in Saugus and the surrounding towns. In 1897 he married Ida F. Chandler, of Lynn, who survives him.

Mr. Hawkes was a quiet man, of a genial disposition, a great reader along literary and scientific lines, fond of gardening, and devoted to his home and his town, in which he held the office of assessor for nine years and that of trustee of the public library for a long period. He was upright, regular and methodical in business and social affairs, and greatly respected by his neighbors and associates.

## WALTER JENNEY.*

Walter Jenney was born in South Boston, February 7, 1856, and died May 8, 1915. He was the son of Bernard Jenney and Mary F. Coney Jenney, who were early settlers and had always been identified with South Boston affairs. His father was born in Boston on the site of the present building at Milk and Oliver streets, and is still living at the age of eighty-eight years.

He graduated from the Bigelow Grammar School and then entered the English High School, from which he graduated in 1872. Shortly after this he entered the Massachusetts Institute of Technology, graduating with the class of '77 in the course of mining engineering, which at that time embraced a large amount of chemical research and investigations. During his course at the Institute he was prominent in many of the student activities,

* Memoir prepared by Richard A. Hale and Arthur L. Plimpton.

which, however, were much less than at the present day. His military experience in the English High School was of value in military affairs at the Institute, and he was appointed captain of one of the companies of the battalion, which at that time was under the command of Lieutenant Zalinski, U. S. A., at that time detailed as military instructor to the Institute. During this period Jenney was one of a committee of '77 who selected the Institute colors of cardinal red and silver gray which were eventually adopted permanently. During his entire course he set high ideals in his studies and conduct and with his genial manner was much beloved by his classmates and professors.

Immediately after graduation he took a position with the Jenney Manufacturing Company as superintendent. This company, of which his father, Bernard Jenney, is president, is engaged in the refining of petroleum, manufacturing of light oils, etc., and is one of the largest concerns in eastern United States.

His technical training and methods of investigation and research enabled him to solve many difficult problems that were constantly arising, and the results have been shown in the successful career which the company has had. In 1900 he was made vice-president and general manager, but still retained his close connection with various details of the business. Notwithstanding his close attention to business he interested himself in public affairs and was a member of the Trade Association of South Boston and served as second vice-president for several years. He took an active part in the agitation for the industrial improvement of the district for better street car service and all civic improvements tending to better conditions.

He was a member of the South Boston Savings Bank and had served for many years on the Board of Investment. He was a member of the Boston Society of Civil Engineers and kept himself informed of technical progress in various lines with which he was connected. He belonged to the Boston City Club, the common meeting ground of many of his business friends and acquaintances. He was also a member of the Masonic fraternity.

He married, June 30, 1880, Elizabeth Bowers Hedge, of

South Boston, who survives him, together with four sons, Herbert H., Charles S., Walter H., and Malcolm. One son, Henry Hedge, died in 1883.

The home life and associations with the large family about him was thoroughly appreciated. He was very musical and was for many years an active member of the Handel and Haydn Association, a good pianist and also church organist, at times substituting for the regular organist at the church which he attended.

He enjoyed nature and outdoor life and was very familiar with the New Hampshire mountains, having made many tramping trips during his summer vacations, and taken many photographs of the scenery.

He was a charter member of the Appalachian Mountain Club and for two years had served as president and held the office at the time of his death. He was a lifelong member of the Hawes Unitarian Church and a constant attendant at services and earnest in matters connected with the parish. He had been chairman of the standing committee of the church for twenty-five years and also chairman of the music committee.

His earnestness and faithful attention to important duties in all his work have shown a strong character that will leave a lasting impression with all with whom he came in contact.

He died of pneumonia after an illness of six weeks, during which time he appeared to be improving, and it was thought that the crisis was past. A change came suddenly and he failed rapidly, passing away quietly Monday, May 8. The last services were held in the Hawes Unitarian Church, which was filled with relatives and friends and representatives from various organizations to which he belonged.

Interment was in Forest Hills Cemetery.

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PAPERS AND DISCUSSIONS

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# SAND AND OIL ROADS AND SURFACES.

By W. R. Farrington,* M.Am.Soc.C.E.

(Presented January 26, 1916.)

The first sand and oil road in this state was constructed by the Massachusetts Highway Commission on Cape Cod, in the town of Eastham, in 1905. In constructing this road, the California method was first followed, but before its completion the so-called "layer method" was adopted.

Some experiments were made with mixed sand and oil for road surfaces in 1908, but the first mixed sand and oil surfaces of any extent were laid in Wareham and Rochester, in 1909. The layer sand and oil roads have therefore been in use in this state for some ten years, and the mixed sand and oil surfaces for six years.

## Layer Roads.

In constructing the road in Eastham, as stated, the California method was first followed. The old road surface, consisting principally of sand of various grades, was roughly shaped and about $\frac{3}{4}$ gal. of hot oil applied per sq. yd. The oil used was similar to that used for hot blankets on macadam or gravel. A

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before April 10, 1916, for publication in a subsequent number of the Journal.

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week or ten days later, a second $\frac{3}{4}$-gal. application of oil was made and the road again harrowed. It was then opened to travel, and eventually covered with a light coating of sand and rolled with a horse roller.

It is probably of interest to note that the distributor used, a large pipe with perforations and sleeve with similar perforations so mounted that it could be revolved and thus vary the size of the openings through which the oil passed, did not apply the oil in a film, but in streaks. Also, the horse-drawn distributor wagon cut the surface badly, causing the oil to settle in the wheel tracks and depressions formed by the horses' feet. The oil was allowed to stand several days, and was then mixed with the sand by a thorough harrowing with a disk harrow.

The construction of this road, and of a similar road in the adjoining town of Orleans, demonstrated, however, that this method was not economical and did not give the best results. Various experiments were made and the "layer method" finally evolved, the roads being completed by this method. It is understood that, with the soil found in those sections of California where the so-called sand and oil roads were constructed quite extensively some years ago, good results are obtained through mixing the oil with the soil by harrowing and by rolling with a tamping roller, provided the road is kept saturated with water during the process. However, to obtain the best results with the sand found in this region, especially on Cape Cod, a different treatment is required.

In constructing a road by the layer method, the subgrade is shaped and any sandy places hardened. Either $1\frac{1}{2}$ gals. of hot oil in two applications, or 2 gals. in three applications, are put on. Sand is spread over the oil after each application, and the road rolled with a horse roller, it being well to do the final rolling with a steam roller, if one is available.

With the $\frac{3}{4}$-gal. application of oil, about $1\frac{1}{2}$ ins. of sand are used for covering; and with the $\frac{2}{3}$-gal. application, about $1\frac{1}{4}$ ins. The $1\frac{1}{2}$-gal. treatment should give eventually a thickness of about $3\frac{1}{2}$ ins., and the 2-gal. treatment, about 4 ins.

If it is desired to confine to one season all work on the road properly chargeable to construction, 2 gals. of oil should be used, otherwise it is advisable to use only $1\frac{1}{2}$ gals. the first season and to apply another $\frac{1}{2}$ gal. the following spring. Experience has demonstrated that any surface constructed of sand and oil by the layer method will be more or less out of shape for some time after the oil is applied, and that weak places will develop. It is principally for this reason that it is more satisfactory and economical to delay the application of the last $\frac{1}{2}$ gal. of oil until the second season. By this method it is possible to find and strengthen any weak places and to remove any inequalities in the surface by scraping with a road machine before the final application of oil.

The heavier grades of oil used for hot blankets are suitable for sand and oil layer work. Some oils with a viscosity as low as 200 seconds,* and others with a viscosity of 845 seconds, have given good results, but usually an oil having a viscosity of from 500 to 600 seconds will give the best results. The specific gravity should be between .98 and 1.00 at 25 degrees C.

A clean, sharp and fairly coarse sand will give the best results, but a comparatively fine sand, even one containing a small proportion of clay or loam, will give good results with the proper grade of oil. Tests made of the sand used on layer work in various places show that the finest sand was such that 24 per cent. passed a 50-mesh screen and only 4 per cent. was retained on an 8-mesh screen, whereas of the coarsest sand 12 per cent. was retained on an 8-mesh screen and only 18 per cent. passed a 50-mesh screen.

The oil should be applied by a distributor which will spread it evenly over the surface. The best results are obtained by the use of a pressure distributor, and usually a horse-drawn machine is preferable to a motor truck, since the ordinary subgrade will not carry a truck without rutting and breaking up. The oil should be shipped and heated in tank cars, but it is advisable to have the distributor carts equipped with steam coils or oil burners, so the oil can be heated in the carts if necessary.

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* In all cases where the viscosity is referred to, the number of seconds given is with the Lawrence Viscosimeter at 100 degrees C. As a basis of comparison, it is to be noted that 100 sec. with the Lawrence Viscosimeter at 100 degrees C. equal approximately 173 sec. with 100 cc. Engler Viscosimeter.

For hardening the subgrade, sandy loam or clay is ordinarily used, two or three inches of either material being sufficient to carry the travel while the surface is being formed. Gravel is preferable, as this will add strength to the surface, but suitable gravel is usually not obtainable in those sections where the sand and oil roads have been constructed by the layer method, and if it is obtainable it is probably advisable to substitute bituminous gravel for the sand and oil.

The surface of a sand and oil road constructed by the layer method should have a crown of not over $\frac{1}{2}$ in. to the foot, and should be at least 15 ft. wide; from 16 ft. to 18 ft. is a more satisfactory width unless the shoulders are hardened, as, if there is any considerable amount of turning out on to soft shoulders, the edges of the sand and oil will be broken down rapidly.

The cost of the surface of sand and oil roads constructed by the layer method has varied from 21 cents to 33 cents per sq. yd., the average cost being 26 cents per sq. yd. This cost does not include grading, culvert work, etc., but does include shaping the subgrade. The average yearly cost of maintenance of the first section constructed in Eastham has been 2 cents per sq. yd., and of other roads constructed at least five years, 1 cent per sq. yd.

## Mixed Sand and Oil Surfaces.

In constructing mixed sand and oil surfaces, the materials were mixed by hand until the fall of 1912. Since then a mechanical mixer has been used with excellent results. The mixer used thus far is an ordinary cube concrete mixer, operated by steam and equipped with a charging device and heating attachment which consists of an oil burner, with air blast, throwing the flame into the mixer. The part with which the flame comes in contact is lined with firebrick.

Previous to the spring of 1915 the sand was heated with the old-fashioned pipe or arch heaters. During the past season a revolving drum heater with oil burners has been used with fairly good results. There is no doubt that such a heater when perfected, as it presumably will be in the near future, will prove economical and will be used extensively. It is somewhat similar to the drum used with an asphalt plant, but the drum is not enclosed, and the flame is thrown directly into one end. There are blades or flanges bolted to the inside of the drum which carry the sand to the top, whence it falls through the hot blast from the burners. The drum is inclined so as to carry the sand slowly to the lower end.

The use of an asphalt plant on sand and oil work has been considered, but the cost of such an outfit and the cost of transportation have been considered prohibitive on work of this nature.

In constructing a mixed sand and oil surface, the subgrade is shaped, and if sandy is hardened with the best material available, usually sandy loam or clay. The sand and oil are heated to the proper temperatures and mixed by hand or by machine. If by hand, the mixing is done on platforms with rakes and hoes, or by turning with shovels. The mixing is continued until all the grains of sand are coated with oil. For this work, from 15 to 25 gals. of oil or oil asphalt have been used per cubic yard of loose sand, but ordinarily the best results have been obtained by the use of about 16 gals. per cu. yd. of sand if loose, or about 18 gals. if compacted. To obtain satisfactory results, the sand must be dry as well as hot. If the sand in the pit when used is fairly dry, it can be mixed in a hot mixer without preliminary heating, but this is not economical, as from five to six minutes are required to mix a batch thoroughly, whereas with hot sand the mixing can be done in about two minutes. The oil, before mixing with the sand, is heated in kettles oı tanks to a temperature of from 250 degrees fahr. to 375 degrees fahr., depending on its nature.

The sand and oil mixture is immediately carted to the road and spread, usually in one course, although under some conditions spreading in two courses may be preferable. The mixture is shaped with rakes and immediately rolled. A horse roller is used for the preliminary rolling, but the surface should be rolled with a tandem steam roller in the course of a few hours. The length of time which should elapse before using the tandem roller depends on the temperature and general weather conditions, but ordinarily any material placed in the morning can be rolled in the afternoon of the same day. During the rolling with steam roller the surface is reshaped with a road machine which removes any inequalities developed during the preliminary rolling. The results obtained on roads not shaped with a suitable scraper during rolling have shown that this work is necessary if the best results are to be obtained on mixed sand and oil work. It is not advisable to use a steam roller for the preliminary rolling, as it tends to force the mixture out of shape when fresh, and to produce an uneven and wavy surface.

Various grades of oils and oil asphalts have been used on mixed sand and oil work, from a hot oil similar to that used for hot blankets, having a viscosity of about 200 seconds, Lawrence Viscosimeter, at 100 degrees C., to oil asphalts having a penetration of from 60 to 150, Dow Penetrometer, at 25 degrees C. Under ordinary conditions, however, the best results have been obtained with oil asphalt having a penetration of from 90 to 125.

If the grains of sand are rounded, and especially if the sizes of the grains vary little, as with ordinary beach sand, a very heavy oil asphalt gives the best results, whereas with sharp sand, well graded, and containing a considerable proportion of grains which will not pass a screen with $\frac{1}{8}$-in. mesh, an oil having a viscosity of from 800 to 1 700 seconds, Lawrence Viscosimeter, at 100 degrees C. gives good results.

Tests made with sand from different pits used for mixed sand and oil work in this state show that of the finest sand used with good results 51.6 per cent. passed a 50-mesh and only 3.6 per cent. was retained on an 8-mesh screen, whereas of the coarsest sand 35.3 per cent. was retained on an 8-mesh and only 11.9 per cent. passed a 50-mesh screen.

It is evident that a fairly coarse sharp sand, the particles of which are well graded, gives the best results. It is also true that a comparatively fine sand, if the grains are sharp and not all of one size, gives satisfactory results, although a heavier oil is required. The coarse sand will probably carry heavier traffic and wear longer.

It is probable that small amounts of clay or loam are not objectionable, but since any large percentage of these materials is detrimental to the work, their use should not be allowed except possibly where the only sand available does not contain a sufficient amount of fine grains to give the proper grading.

The addition of from 5 to 10 per cent. of cement gives a more dense and stronger mixture, but of course increases the cost. Cement has not as yet been used on this work long enough to determine whether the results warrant the additional cost.

While it is possible to construct a mixed sand and oil surface on sand without hardening the subgrade, provided the mixture is spread in two courses, it has been proved that this is not economical and that the results are not satisfactory unless the thickness is increased. The subgrade will be cut up by the teams used on the work and the sand mixed with the surface during the rolling, causing weak places and an uneven surface. Also, the thickness will not be uniform and the surface will naturally be only as strong as the weakest sections. Moreover, if the subgrade is not hardened, the cost of shaping and rolling will be considerably increased, since to obtain good results it is necessary that the surface of the lower course be reasonably smooth before the second course is spread, as any considerable inequalities in the lower course will be reproduced eventually in the finished surface of the road.

After the sand and oil mixture has been thoroughly rolled, the surface is sealed by the application of hot oil having a viscosity of from 250 to 600 seconds, Lawrence Viscosimeter, at 100 degrees C. at the rate of $\frac{1}{2}$ gal. per sq. yd. The oil is spread by a pressure distributor in two $\frac{1}{4}$-gal. applications, each followed by a light covering of sand. This coat not only seals the surface of the mixed sand and oil but also adds about $\frac{1}{2}$ in. to the thickness.

A mixed sand and oil surface should have a crown of not over $\frac{1}{2}$ in. to the foot, and should be not less than 18 ft. wide, since with mixed sand and oil, even more than with a surface constructed by the layer method, the edges will be rapidly broken down if there is any considerable amount of driving from the sand and oil surface on to the shoulders. The thickness should be from $3\frac{1}{2}$ to 4 in. before the seal coat is applied.

The cost of mixed sand and oil surfaces, including the seal coat, has varied from 40 cents to 61 cents per sq. yd., the average

### Table of Oil Tests.

| Town. | Oil Used for Mixing. Sp. Gravity. | Penetration, 25° C. | Insol. Car. Bis. | Insol. 88 B. Naphtha. | Evap. 5 Hrs. at 325°. | Oil for Seal Coat. Sp. Gravity. | Viscosity 100° Lawrence Viscosimeter. | Insol. Car. Bis. | Insol. 88 B. Naphtha. | Evap. 5 Hrs. at 325°. |
|---|---|---|---|---|---|---|---|---|---|---|
| Bourne, E., 1914 | 1.02 | 135 | 1.2 | 23.4 | 0.5 | 1.00 | 530 | 0.1 | 18.5 | 3.1 |
| | 1.03 | 118 | 0.1 | 23.1 | 0.4 | | | | | |
| Mashpee 1912 | .995 | 125 | 0.0 | 23.0 | 6.4* | | | | | |
| Mashpee 1913 | 1.01 | 150 | 0.6 | 27.8 | 13.2 | .985 | 700 | 1.0 | 19.1 | 16.5* |
| Plymouth 1912 | .995 | 110 | 0.0 | 21.5 | 2.4* | | | | | |
| Plymouth 1913 | 1.03 | 118 | 0.1 | 22.7 | 0.3 | .997 | 660 | 0.1 | 17.1 | 13.1 |
| Provincetown, 1914 | | | | | | | | | | |
| Sandwich 1912 | 1.00 | 100† | 1.7 | 18.5 | 0.2* | | | | | |
| Sandwich 1913 | 1.00 | 150 | 0.2 | 26.7 | 10.7 | | | | | |

* Evaporation 12 hrs. at 250 degrees.
† Penetration at 20 degrees C.

### Table of Sand Tests.

| | Layer Method. Eastham, 1909, Stand. A. | Harwich, No., 1908. Stan. A. | Plymouth, 1913. Stan. B. | Mixed Sand and Oil. Bourne, E., 1914. Stan. B. | Bourne, E., 1914. Stan. C. | Mashpee, 1913. Stan. B. | Sandwich, 1912. Stan. B. Hand Mixed. |
|---|---|---|---|---|---|---|---|
| Passing 200 Mesh | 1.5 | 5.2 | 1.5 | 1.5 | 1.2 | 2.2 | 7.2 |
| 100 | 2.0 | 3.3 | 3.2 | 2.9 | 2.6 | 1.0 | 14.7 |
| 80 | 2.3 | 2.8 | 3.2 | 3.5 | 1.8 | 1.8 | 9.5 |
| 50 | 12.5 | 12.1 | 18.6 | 19.4 | 6.3 | 11.2 | 20.2 |
| 40 | 8.6 | 12.7 | 9.9 | 7.3 | 2.8 | 9.4 | 8.9 |
| 30 | 14.3 | 18.1 | 19.5 | 18.2 | 7.6 | 15.4 | 11.4 |
| 20 | 20.3 | 26.5 | 20.1 | 18.1 | 14.7 | 22.3 | 13.9 |
| 10 | 23.0 | 15.1 | 12.8 | 13.0 | 21.4 | 21.6 | 9.1 |
| 8 | 4.0 | 1.1 | 1.4 | 2.6 | 6.3 | 3.2 | 1.5 |
| 4 | 11.5 | 3.1 | 9.8 | 4.3 | 12.1 | 11.9 | 3.6 |
| 2 | | | | 9.1 | 13.7 | | |
| Retained 2 | | | | | 9.5 | | |
| Summary | | | | | | | |
| Passing 50 Mesh | 18.3 | 23.4 | 26.5 | 27.3 | 11.9 | 16.2 | 51.6 |
| Retained 8 Mesh | 11.5 | 3.1 | 9.8 | 13.4 | 35.3 | 11.9 | 3.6 |

being 52 cents. This cost is for the surface alone and does not include grading, culvert work, etc. The average yearly cost of maintenance for those roads which have been in use at least five years is 1.6 cents per sq. yd., and for those in use three years $\frac{3}{4}$ cent per sq. yd.

The first mixed sand and oil surfaces were not sealed when constructed, but a seal coat was applied a year or two later. None of the roads have as yet been resealed, but a seal coat will probably have to be applied once in four or five years at a cost of about 6 cents per sq. yd. If so, this will increase the yearly cost of maintenance to about $2\frac{1}{2}$ cents per sq. yd.

## Traffic.

The amount of traffic a sand and oil road will safely carry is as yet somewhat problematic. It is probable that there has been no instance in this state where a sand and oil road of either type has failed, if properly constructed of suitable material. On the other hand, the layer roads have been constructed only in those sections where the travel is comparatively light, and none of the mixed surfaces have been subjected to any very large amount of heavy traffic.

It is true that some heavy loads have passed over both types of roads, as, for instance, in the transportation of bituminous materials by motor trucks weighing, with load, about 14 tons, but the number of such loads in any one season has been small. Under these loads the layer roads have shown some evidences of weakness, but there has been no indication of failure with the mixed surfaces. That neither road will carry a large amount of horse-drawn traffic alone is evidenced by the fact that such surfaces have in several instances been badly cut up by the passage of a troop of cavalry or a large number of transport wagons during army maneuvers, but this is also true of either hot or cold blankets on macadam.

It has also been observed that a mixed sand and oil surface which has carried successfully quite a heavy traffic during the summer, when the proportion of motor travel was comparatively large, has been consideiably cut up in the spring before the motor traffic season commenced, although evidently the actual number of horse-drawn vehicles was much less in the spring than during the summer.

It seems probable, from the experience thus far gained with sand and oil roads in this state, that the layer road will carry only a light traffic and is a suitable type of road only where the conditions will not warrant a more expensive surface. Aside from the amount of traffic a layer road will carry, it is probably impossible to obtain by this method as satisfactory a surface as by the mixed method. However, if the travel is light, not only can a surface be constructed at a comparatively small cost by the layer method, but such a surface can be economically maintained.

A mixed sand and oil surface will probably carry quite a heavy traffic, provided the proportion of horse-drawn vehicles is not excessive, but presumably not so heavy as bituminous macadam or bituminous gravel. While the mixed sand and oil surfaces have been very satisfactory on Cape Cod and in other sections where the travel and conditions are similar, it has not been considered advisable, thus far, to construct these surfaces where there is a considerable amount of heavy traffic, provided broken stone of a satisfactory quality or material suitable for bituminous gravel can be obtained at a reasonable cost. Experiments are being made, however, with different grades of sand and different bituminous materials, and it is probable that some combination will be found which will give a denser mixture and a firmer surface, one which will carry heavier loads and stand up better under horse-drawn traffic than the ordinary mixed sand and oil surface. To obtain this result it may be necessary to vary the grading of the sand found in the ordinary pit by combining the finer with the coarser grades, or by the addition of cement. It is also probable that a heavy asphalt, or oil asphalt, will have to be used. If such a mixture can be obtained at a reasonable cost, it will be possible, by the use of a 3-in. or 4-in. base of the ordinary mixture with a 2-in. or 2½-in. wearing surface of the denser mixture, to construct a surface of sand and asphalt, or oil asphalt, which will carry heavy traffic economically and will compare favorably with bituminous gravel or bituminous macadam.

## Bituminous Gravel.

While it is probably not within the province of this paper to consider bituminous gravel surfaces in detail, a brief mention of them would seem pertinent since these surfaces have been developed in connection with the sand and oil work, and the methods followed in their construction are similar.

In constructing these surfaces, gravel is spread on the subgrade to a depth sufficient to give 4 or 5 in. after rolling, the gravel being watered and thoroughly compacted with a steam roller. The top course or wearing surface consists of a mixture of oil, or oil asphalt, and gravel $2\frac{1}{2}$ ins. thick after rolling, this also being compacted with a steam roller. Either a tandem or a regular macadam roller can be used, but the former is preferable. Rather more bituminous material is used for mixing than with sand and oil work, but not over 20 gals. per cu. yd. of gravel should be required. With this surface a seal coat is not necessary.

The best results are obtained by using for both courses a binding gravel or one which can be compacted without the addition of any bituminous material.

It is probable that a bituminous gravel surface will carry as heavy traffic, and will wear at least as long, as bituminous macadam.

Either bituminous gravel, or sand and oil, can be used with excellent results for resurfacing old water-bound macadam.

## Specifications for Sand and Oil Layer Work.

The road shall be graded for a width of twenty-one (21) feet in cuts and twenty-five (25) feet on fills. The slopes outside the graded roadway shall be left in a neat condition.

Any clay or other material in the subgrade which, if left, would cause frost action detrimental to the road surface, shall be removed to the depth ordered by the engineer, and replaced with suitable material, and any sandy places shall be hardened as ordered. For this purpose, sandy loam or clay may be used, but if used, only enough of these materials shall be placed on the subgrade to carry the travel while the surface is being formed, and in no case shall the depth of such hardening material exceed three (3) inches after rolling.

The subgrade shall be shaped to correspond with the proposed cross-section of the finished road and shall be rolled with a horse roller, unless otherwise ordered.

On the roadbed prepared as hereinbefore described, asphaltic oil shall be applied for a width of fifteen (15) feet, unless otherwise ordered.

The oil shall be shipped to the nearest railroad freight station in tank cars and transported to the work in suitable distributor carts. It shall be heated in the tank cars or distributor carts, so that when applied it shall have a temperature of not less than 180 degrees fahr. nor more than 250 degrees fahr. The oil shall be applied to the road by a pressure distributor which will spread it evenly over the surface, leaving no spots or streaks uncovered, and no overlapping will be allowed.

The distributor shall be so arranged that the operator can control the flow and can cut out sections so as to vary the width of the road covered.

If two (2) gallons of oil per square yard are to be used in forming the surface, the oil shall be distributed in three applications of approximately two thirds ($\frac{2}{3}$) of a gallon per square yard. If one and one-half ($1\frac{1}{2}$) gallons are used, there shall be two three-quarter ($\frac{3}{4}$) gallon applications.

Immediately after the oil is applied, a uniform layer of sand shall be spread over it, the depth of the sand to be approximately one and one-quarter ($1\frac{1}{4}$) inches for the two-thirds ($\frac{2}{3}$) gallon application, and one and one-half ($1\frac{1}{2}$) inches for the three-quarter-gallon application. Each layer of sand and oil shall be rolled with a horse roller, and if ordered, the road, before its acceptance, shall be rolled with a steam roller. During the rolling, sand shall be applied to absorb any oil flushing to the surface.

Each layer of sand and oil shall be allowed to stand a sufficient length of time so the oil will mix with the sand, and there shall be no surplus sand or free oil on the surface when the next application of oil is made.

The asphaltic oil used shall be as ordered, but in no case shall oil with a viscosity of less than 250 seconds, or more than 600 seconds, Lawrence Viscosimeter at 100 degrees C., be used.

The sand used shall be clean, sharp and free from adventitious materials of all kinds, but if so ordered may contain not over 5 per cent. of clay or loam. It shall contain no stones larger than one-half ($\frac{1}{2}$) inch in their longest dimensions, or more than 30 per cent. passing a 50-mesh screen.

If at any time before the acceptance of the work any soft or imperfect places develop, the material at these places shall be removed and replaced with new material and rolled until thoroughly compacted and until the joints between the new and old work become invisible.

Any inequalities in the surface shall be removed by scraping with a road machine, or other suitable scraper.

After the surface has been completed to the satisfaction of the engineer, and before the acceptance of the work, a light covering of sand shall be spread evenly over the surface.

The surface of the road when completed shall have a crown of one-half ($\frac{1}{2}$) inch to the foot.

No bituminous work shall be done during rainy weather, nor when the weather conditions as to temperature or otherwise are unfavorable for obtaining satisfactory results.

If the oil is furnished by the party of the first part, it shall be delivered in tank cars at the railroad freight station nearest the site of the work. It shall be ordered when and as requested by the contractor, who shall be responsible for any railroad demurrage or other charges incurred, or for any loss or damage to the material which may accrue after its delivery at the railroad station selected.

## Specifications for Mixed Sand and Oil Work.

The road shall be graded for a width of from twenty-one (21) feet to twenty-four (24) feet in cuts, and from twenty-five (25) feet to twenty-eight (28) feet on fills, as ordered by the engineer.

The slopes in cuts and on fills shall conform to lines and grades given, and shall be left in a neat condition.

All clay or other material in the subgrade which, if left, will cause frost action detrimental to the road surface shall be removed to the depth ordered by the engineer and replaced with suitable material. Any sandy places shall be hardened as ordered. For this purpose, sandy loam or clay may be used, but if used, only enough of these materials shall be placed on the subgrade to prevent its being cut up and the sand mixed with the surface during construction.

In no case shall the depth of such hardening material exceed three (3) inches after rolling.

Before the surface is placed, the subgrade shall be thoroughly rolled, a steam roller being used, unless otherwise ordered by the engineer, and the subgrade shall be left with a true surface conforming to the proposed cross section of the finished road.

On the roadbed prepared as hereinbefore described, the sand and oil surfacing shall be applied as follows:

The sand and oil shall be mixed by hand or in a mechanical mixer. If by hand, the mixing shall be done on platforms with rakes and hoes, or by turning with shovels. The platforms shall be made of two (2) inch planks, and shall be about eight (8) feet wide by sixteen (16) feet long, but for convenience in handling may be made in two sections.

If a mechanical mixer is used, it shall have a suitable hot attachment, so arranged that the materials will not be burned during the mixing.

The oil shall be heated in tanks or kettles of a design satisfactory to the engineer, and having a capacity of not less than sixty (60) gallons.

The contractor shall furnish and operate a sufficient number of heating kettles, sand heaters and platforms, if the mixing is by hand, to handle the work expeditiously.

If, in the opinion of the engineer, the work at any time is not proceeding with sufficient rapidity to insure its completion within the time specified in the contract, the contractor shall furnish and operate additional kettles or tanks, sand heaters and platforms, as ordered.

The oil shall be heated to a temperature of from 250 degrees fahr. to 375 degrees fahr., depending on the nature of the oil or oil asphalt used.

The sand when mixed with the oil shall be dry and so heated that a uniform mixture will be secured. Care must be exercised not to overheat the sand so as to burn the oil.

If mixed by hand, the sand shall be spread on the platforms, the hot oil poured over it and the sand and oil mixed with rakes and hoes, or by shovels. If mixed by machine, the sand shall be placed in the mixer before the oil is poured in.

The mixing, whether by hand or machine, shall be continued until all the particles or grains of sand are coated with oil. When the mixing is completed to the satisfaction of the engineer, it shall be transported immediately to and spread on the road. It shall not be dumped directly on the subgrade, but upon dumping boards or iron plates; the dumping boards or plates to be of sufficient size to retain all of the mixture when dumped.

The mixed material after it is deposited in place shall be shaped with rakes and immediately rolled with a horse roller weighing about one (1) ton. The surface shall be shaped with a road machine or suitable scraper and afterwards rolled with a tandem steam roller. The length of time elapsing before rolling with the steam roller shall be as ordered by the engineer.

Any depressions appearing in the surfacing shall be filled with mixed material satisfactory to the engineer. If such depressions are found after the sand and oil have hardened so the new material will not bond readily with the old, a sufficient amount of the old material shall be dug out to allow the placing of not less than two (2) inches of the new mixture, which shall be thoroughly rolled.

Any slight unevenness of the surface shall be remedied by scraping with a road machine or suitable scraper and the surface again rolled.

The sand and oil surfacing shall be eighteen (18) feet wide, four (4) inches thick in the center and three and a half ($3\frac{1}{2}$) inches on the sides after rolling, and shall have a crown of one-half ($\frac{1}{2}$) inch to the foot, unless otherwise ordered by the engineer.

The mixture shall be spread in two courses if ordered. In this case, each course shall be rolled, shaped with a suitable scraper and afterwards rolled with a steam roller, and the top course shall not be spread until a firm and even surface, true to line and grade, is obtained on the lower course.

The oil or oil asphalt used for mixing shall be as ordered, but in no case shall oil having a viscosity of less than 500 seconds, Lawrence Viscosimeter at 100 degrees C., or oil asphalt having a penetration of less than 60, Dow Penetrometer at 25 degrees C., be used.

The amount of oil used shall be as ordered, but in no case shall less than fifteen (15) gallons or more than twenty (20) gallons be used per cubic yard of loose sand.

The sand shall be clean, sharp, fairly coarse and well graded, and shall contain no adventitious material of any kind. It shall contain no stones more than one-half ($\frac{1}{2}$) inch in their longest dimensions, or over 52 per cent. passing a 50-mesh screen.

After the sand and oil mixture has been shaped and rolled to the satisfaction of the engineer, a seal coat of asphaltic oil shall be distributed on the surface in two (2) applications of one-quarter (¼) of a gallon per square yard.

Each application of oil shall be covered with a thin layer of sand spread evenly over the surface and rolled with a steam roller, additional sand being added as needed to absorb any oil flushing to the surface. The asphaltic oil used for the seal coat shall be of a grade satisfactory to the engineer, but in no case shall oil having a viscosity of less than 250 seconds, or more than 600 seconds, Lawrence Viscosimeter at 100 degrees C., be used.

The oil shall be heated in tank cars or otherwise and shall be transported to the work in suitable distributor carts or trucks. It shall have a temperature of approximately 250 degrees fahr. when applied.

The oil shall be applied by a pressure distributor which will spread it evenly over the surface, leaving no spots or streaks uncovered, and no overlapping will be allowed.

The distributor shall be so arranged that the operator can control the flow and cut-out sections, so as to vary the width of road covered.

The sand used for the seal coat shall be clean, sharp and free from adventitious materials of all kinds, but may contain not over 5 per cent. of clay or loam, if so ordered. It shall contain no stones larger than one-half (½) inch in their largest dimensions, or more than 52 per cent. passing a 50-mesh screen.

The contractor shall sprinkle the subgrade or surface of the road with water, when and as directed by the engineer.

If at any time before the acceptance of the work, soft or imperfect places develop in the surface, the material at all such places shall be removed and replaced with new mixed material, and these sections shall be re-rolled until the new material is thoroughly compacted and the joints between the new and old material become invisible. In repairing imperfect places, the old material shall in all cases be removed to a depth sufficient to allow the placing of at least two (2) inches of the new mixture. If such work is done after the seal coat has been applied, all sections so disturbed shall be resealed. No extra allowance shall be made the contractor for removing and replacing unsatisfactory material.

No bituminous work shall be done during rainy weather nor when the weather conditions as to temperature or otherwise are, in the opinion of the engineer, unfavorable for obtaining satisfactory results.

If the bituminous materials are furnished by the party of the first part, they shall be delivered at the railroad freight station nearest the site of the work. These materials shall be ordered when and as requested by the contractor, who shall be responsible for all railroad demurrage, storage or other charges incurred and for any loss or damage to the materials that may accrue after their delivery at the railroad station selected.

The oil or oil asphalt for mixing shall be shipped in barrels, and the oil for seal coat in tank cars.

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PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

# SOME MINOR PROBLEMS IN A HIGHWAY BRIDGE DESIGN.

By L. M. Hastings,* Member Boston Society of Civil Engineers.

The highway bridge at Walden Street, Cambridge, over the main line of the Fitchburg Division of the Boston & Maine Railroad, has a width of 42 ft. between sidewalk railings, and a length between abutment bearings of 61 ft. This bridge, as constructed in 1892, had two main steel plate girders with steel floor beams carrying the floor joists of hard pine. The floor was of 3-in. hard pine covered with 2-in. spruce. The sidewalks were carried on steel brackets.

The railroad here has four tracks and is built on an ascending grade going west. The clearance between the rails and bottom chords of the bridge was only about 15 ft. 6 in. This brought the tops of the engine smokestacks very close to the lower members of the bridge, with consequent rapid loss of metal by the mechanical effect of the blast, besides the chemical action of the smoke and gases upon all exposed surfaces. Various means were tried to protect the more exposed portions of the steel members from these effects. A heavy coating of asphaltic paint, cement mortar held with expanded metal and heavy sheet lead, were tried with only indifferent success. Finally, the por-

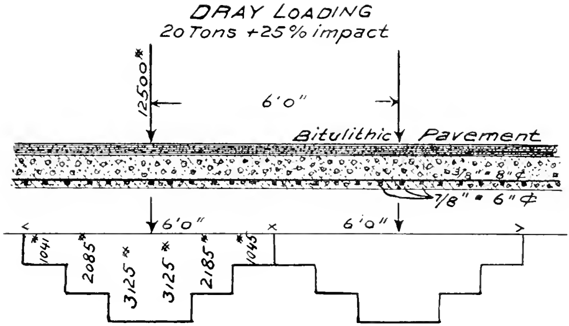
* City Engineer, Cambridge, Mass.

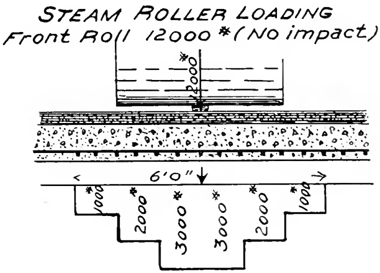
tions of the members exposed to the direct action of the blast from engines were covered with $\frac{7}{8}$-in. plain oak sheathing held firmly in place with iron clamps, the sheathing first being thickly covered on its upper side with a paste composed of red lead and Portland cement. This was found to work very well, the oak sheathing showing surprising resistance to the destructive action of the blast. Some pieces of oak taken from the bridge after ten or twelve years' exposure showed a loss of not over $\frac{1}{4}$ in. in thickness.

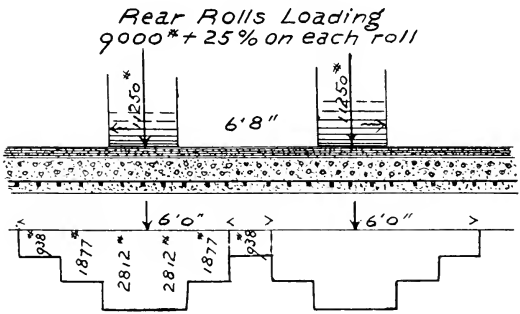
The portions of the metal not so protected were, of course, exposed to the continued action of the smoke and gases and continual repairs were necessary to keep the bridge even fairly safe. The first cost of the bridge superstructure in 1892 was $3 063.80. The total cost of maintenance and repairs on the bridge from its erection to 1913 was $3 815.85. ' In 1913 the bridge had become so weakened that it was declared to be unsafe for travel, and in 1914 it was decided to build a new one in its place.

The new bridge is carried on three main plate girders 63 ft. long and 42 ft. between centers of the two outer ones. The entire floor for roadways and sidewalks is of reinforced concrete slabs carried by steel beams so arranged that no slab shall be of more than eight feet span.

In designing the details of this bridge, two rather interesting problems were encountered. The first related to the distribution of the assumed concentrated live loads upon the floor slabs, from which the proper amount of steel reinforcement could be determined. The slab itself was assumed to be about 9 in. thick and to be covered with a bitulithic pavement about 4 in. thick. The usual live loading for that class of bridge was taken, namely, a four-wheeled dray weighing, loaded, 20 tons, with wheels 6 ft. apart and axles 12 ft. apart, or a steam roller weighing 15 tons with rolls 11 ft. apart, and with 20 per cent. additional for impact and vibration in computing stresses. No data as to the distribution of such loads on the floor slabs under these conditions being available, an empirical assumption had to be made. The conditions of loading producing maximum stress would be as shown on the accompanying diagrams. While it was clear


DRAY LOADING
20 Tons +25% impact
12500*
6'0"
Bitulithic Pavement
3/8" = 8"
7/8" = 6"
6'0"
6'0"
1041*
2085*
3125*
3125*
2185*
1045*


STEAM ROLLER LOADING
Front Roll 12000*(No impact)
12000*
6'0"
1000*
2000*
3000*
3000*
2000*
1000*


Rear Rolls Loading
9000*+25% on each roll
11250*
11250*
6'8"
6'0"
6'0"
938*
1877*
2812*
2812*
1877*
938*

that the slab had some degree of flexibility and must show deflection under loading, it was assumed that the concrete, bonded laterally by the cross reinforcing rods, would distribute the stresses over a considerable distance. After trying various assumptions for distributing the stresses, the one shown on the stress diagrams was finally adopted.

On the first, it was assumed that the load of 12 500 lbs. was carried equally by the reinforcement on either side of its point of application, and that the influence of one half of this load, or 6 250 lbs., would be extended for a distance of three feet from its point of application in a diminishing amount, and that one half of that amount, or 3 125 lbs., would be carried by reinforcement in the first foot, one third, or 2 085 lbs., in the second foot, and one sixth, or 1 045 lbs., in the third foot, making the entire load to be carried by the reinforcement in a strip of floor six feet wide.

In the second case, the front roll of the steam roller was considered. In this the entire load of 12 000 lbs. was assumed as applied at one point but without the 25 per cent. addition for impact, as it was thought that if impact was produced by the roll, as in passing over a stone, it could be only when the roll was returned to the surface and the load was then automatically distributed by the roll itself. The flexible hanging of the front roll would also assist this distribution. The assumptions for distribution were as before. The greatest load in this case would be 3 000 lbs. per foot.

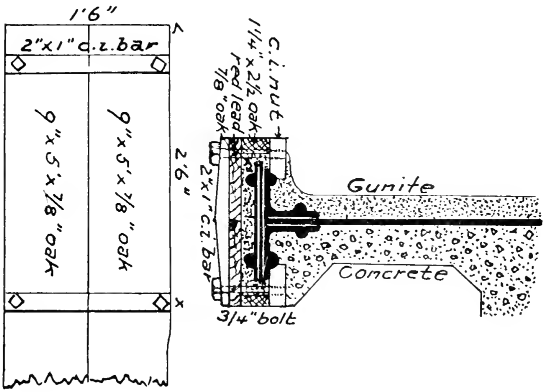
In the third case, the rear rolls of the roller were considered, and the assumptions as to load distribution were the same as in the first case. The maximum loading in this case would be 2 812 lbs. per foot.

The loading used in determining the amount of reinforcement required was 3 125 lbs. per foot applied in the center of the span.

Before the bridge was completed, the contractors for the paving rolled it with a fifteen-ton roller, passing it repeatedly back and forth over the bridge. The deflection was so small as to be unnoticeable.

The second problem related to the best method of covering the exposed sides of the two outer girders. They are seven feet high, and to cover them with cast concrete was difficult unless the covering was made rather thick. If the covering was cast thick enough to be practicable, the dead load was greatly increased. It was therefore proposed to use the " Cement Gun " and apply the covering only about two inches thick. When the bids were received, however, it was found that the price de-

DETAIL OF FLANGE COVER




manded for the use of this method was excessive, due to the unfavorable position of the surfaces to be treated over the constantly passing trains beneath. It was suggested that the " gunite " be applied to the girders at the shop after they were fabricated, and that then they might be shipped to the site on the cars. The contractors for the bridge finally adopted and carried out this plan with entire success. The two girders were given a covering of " gunite " in the yard of the shops and were transported on cars to the site and the bridge erected without starting a crack, so far as could be discovered. The " gunite " forms a dense, firm covering which seems to adhere with great tenacity to even the smooth surfaces of steel plate.

Where the railroad tracks pass under any of the main or secondary members of the bridge, the bottom flanges are protected with the oak covering already described, and shown on the accompanying diagram. Twenty-four of these oak coverings, each five feet long, were used on the new bridge.

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PAPERS AND DISCUSSIONS



# PAN-AMERICAN USE OF THE METRIC SYSTEM.

By Frederick Brooks,* Member Boston Society of Civil Engineers.

Almost every human activity has to do with weights and measures; the matter is one about which men are conservative, and the power of habit makes it hard to bring about changes. From the mass of facts and experiences a few particulars which concern the Boston Society of Civil Engineers are here picked out. This Society officially petitioned Congress, in 1876, praying it to "enact that, after some date to be fixed several years in advance, the metric standards in the Office of Weights and Measures at Washington shall be the sole authorized public standards of weights and measures."

Under date of April 5, 1893, announcement was made in Bulletin No. 26 of the U. S. Coast and Geodetic Survey, signed by T. C. Mendenhall, Superintendent of Standard Weights and Measures, and approved by J. G. Carlisle, Secretary of the Treasury, that

> "the Office of Weights and Measures, with the approval of the Secretary of the Treasury, will in the future regard the international prototype meter and kilogram as fundamental standards, and the customary units, the yard and the pound, will be de-

Note. This paper will be presented for discussion at a special meeting for which a date has not yet been set.

* 31 Milk Street, Boston.

rived therefrom in accordance with the Act of July 28, 1866. Indeed, this course has been practically forced upon this office for several years," etc.

Dr. Mendenhall stated this in his paper on "Fundamental Units of Measure," prepared for the International Engineering Congress of the Columbian Exposition, 1893, which was printed in the *Transactions of the American Society of Civil Engineers*, Vol. XXX, pp. 120–134. He also stated (p. 130), —

> "The most important legislation upon this subject from the founding of the Government to the present time is the Act of Congress of July 28, 1866, legalizing the metric system of weights and measures throughout the United States. It has not been generally recognized that this system is and has been for more than a quarter of a century the only system whose use is made legal throughout the whole country by Act of Congress."

In the third edition (1879) of the "Metric System" by Dr. F. A. P. Barnard, long president of Columbia College, he wrote of what several organizations had done in promotion of the metric reform, saying (p. 321), —

> "A few, not limiting themselves to the public expression of their own views, have sought, by correspondence and by gathering and diffusing information on the subject, to operate upon public opinion, and to stir up others to similar action. In efforts of this nature the Boston Society of Civil Engineers has been especially distinguished."

Dr. B. A. Gould, the astronomer, member, for the U. S. A., of the International Committee of Weights and Measures, in addressing the Boston Society of Civil Engineers, March 12, 1890, used the following words, which may well be quoted now (see *Journal of the Association of Engineering Societies* for June, 1890, Vol. IX, p. 289):

> "Speaking to a society which has already advocated the introduction of the metric system in a manner and at a time which has insured it a most honorable place in history, and to men whose professional pursuits are constantly tending to impress upon them the importance of the reform, I need say nothing in its behalf. But I am most desirous of using this opportu-

nity to urge upon you that now is the time for renewing an earnest and vigorous effort in its behalf."

It is now nearly twenty years since the Boston Society of Civil Engineers has been canvassed on the question. In the *Journal of the Association of Engineering Societies* for December, 1896, under "Proceedings" (Vol. XVII, pp. 21–2), is the following report, October 21, 1896, from the Committee on Weights and Measures:

"Postal cards reading as follows were sent to each member:

'I am ........ in favor of the passage by the present Congress of an Act requiring the metric weights and measures to be in use by the government departments generally by the beginning of the twentieth century, January 1, 1901.

'I should ........ be willing to have people generally of their own accord adopt metric weights and measures for their ordinary business transactions, and especially for those in which I am myself concerned, at the same time at which the government departments as a whole actually do adopt them.'

| | |
|---|---|
| "The total number of cards sent out was................ | 404 |
| The total number of cards returned was................ | 229 |
| Number in favor of both clauses of the card............ | 193 |
| Number against both clauses of the card............... | 21 |
| Number for first clause and against second............. | 2 |
| Number against first clause and for second............. | 11 |
| Members in favor of a decimal system.................. | 2" |

At an earlier date there had been a canvass reported by the Committee on Weights and Measures, along with various remarks in discussion of the subject by a number of members of the Society, which is printed in the *Journal of the Association of Engineering Societies* for July, 1888, Vol. VII, pp. 264–271. Among other things it is stated that there were 57 affirmative replies and 19 negative ones to question (D), — "Is the ultimate exclusive adoption of the metric system throughout the United States desirable?"

In connection with that report is a statement (p. 265) under date of May 26, 1888, of what had been accomplished two days before; thus, —

"Congress has made an enactment (approved by the

President, May 24, 1888) which is likely to be decisive as to the adoption of the metric system in our custom houses. It authorizes the President of the United States to invite the several governments of the republics of Mexico, Central and South America, Hayti, San Domingo, and the empire of Brazil, to join the United States in a conference to be held at Washington at such time as he may deem proper in the year 1889, to consider, among other things, the formation of an *American Customs Union*, and the adoption of a *uniform system of weights and measures*."

In another report of the committee, nearly two years later, the result of that International American Conference (to which the appellation of First Pan-American has often been given more recently) was stated with quotation of the resolution it adopted, as follows (Vol. IX, p. 332):

"That the International American Conference recommends the adoption of the metrical decimal system to the nations here represented, which have not already accepted it."

This was referred to in successive Reports of the Committee on Coinage, Weights and Measures of the House of Representatives in the following language:

"In 1888 (by resolution of May 24) this country invited the republics of Central and South America, Mexico, Hayti, and San Domingo to a conference to be held in the city of Washington, to consider among other things 'the adoption of a uniform system of weights and measures.' The invitation was accepted; the conference was held. To the extent of its power it adopted a uniform system of weights and measures. The other nations, parties to the conference, with scarcely an exception have honorably proceeded to put in force in their respective limits the metric system thus adopted. On what principle of international honor can the United States, the originator of the conference, stand alone in refusing or delaying to abide by its action?" . . . "Having sought the verdict of a tribunal of our own choosing, shall we fail to stand by its decision? A nice sense of honor no less than her own interests would seem to demand from the United States definite and complete action which should put her in full accord on this subject with the nations with which she has so long ostensibly been coöperating." (H. of R. Reports No. 795, 54th Cong., 1st Sess. (March 16, 1896); 2885, 54th Cong., 2d Sess. (Feb. 10, 1897); 1597, 55th Cong., 2d Sess. (June 29, 1898).

Information as to the Second Pan-American Scientific Congress has been kindly furnished by one who took part in it, Elmer L. Corthell, now president of the American Society of Civil Engineers. He has been a member of the Boston Society of Civil Engineers for the last thirty years. The following are the

RESOLUTIONS ADOPTED BY THE ENGINEERING SECTION OF THE CONGRESS, SUBMITTED TO THE GENERAL SESSION FOR APPROVAL, CONCERNING THE METRIC SYSTEM.

"*Whereas*, in the western hemisphere, the English system of weights and measures is in use only in the United States and Canada, while the remaining American republics and the greater part of the eastern hemisphere use the metric system;

"*Whereas*, the system of measures and weights is an important part of the vocabulary in international relations;

"*Whereas*, the English system is not nearly as convenient and simple as the metric system is, either in commercial or scientific work;

"*Whereas*, the use of the English system in the United States is one of the important obstacles to a closer commercial and scientific intercourse and coöperation between the United States and the other of the American republics;

"*Whereas*, a general change from the English to the metric system in the United States would be a great benefit not only economically but also in promoting international good-will and mutual understanding;

"*Be it therefore resolved*, that this Congress favors all proper steps and measures to bring about a general use of the metric system of weights and measures in the United States, in the press, in educational and scientific work, in the industries, in commerce, in transportation and in all the activities of the Government."

Verbal amendments being made, the " final Act " included the following (Section V):

" That proper steps and measures be taken to bring about in the American republics participating in the Congress a general use of the metric system of weights and measures, in newspapers and magazines, in educational and scientific work, in the industries, in commerce, in transportation and in all the activities of the different governments."

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# DISCUSSION OF THE FEDERAL VALUATION OF THE BOSTON AND MAINE RAILROAD.

By Messrs. Wm. J. Cunningham, J. C. Irwin and H. V. Hayes.

Professor Cunningham.* — I did not come to-night prepared to speak on the subject, but, knowing Mr. Shepherd very well and having some connection with the Boston and Maine, I am very much interested in the subject which he has so very well explained. In fact, it is an admirable treatise on a colossal waste of energy. Looking at it from a broad viewpoint, it is hard to preserve one's equanimity in thinking of an expenditure of fifty or sixty millions which is not going to amount to anything. This equals the gross earnings of the Boston and Maine and Boston and Albany combined, for one year, or the net income of something like fifteen or twenty thousand miles of railroad for one year.

I should like to be as optimistic as Mr. Shepherd is in his statement that this valuation will be the basis of the rates fixed by the Interstate Commerce Commission. In my opinion, there can be but a very remote connection between valuation and rates. The valuation of the Boston and Maine will show undoubtedly that the road, on the basis of its valuation, is entitled to many times the returns which it now is getting. But

* Professor of Transportation, Harvard University.

will that enable the Boston and Maine to increase its rates? What will be the relation of the valuation of its competitors? What effect will the valuation of the Lackawanna Railroad, with its wonderful and costly engineering work, have on the rates between New York and Buffalo in competing with a water-grade line, — the New York Central? Valuation may have some academic bearing on the general scale of rates, but we must underscore the word "academic." I don't think it will have any practical value whatever, and in any event the results of this valuation are going to be so disappointing to the statesmen who fathered the idea that in my opinion the valuation will never be finished and the figures will never be known in their entirety.

The whole thing seems to be a fundamental violation of an engineering principle. An engineer is supposed to get something more than a dollar for the expenditure of a dollar. If the Boston and Maine Railroad could only utilize the splendid services of Mr. Shepherd and his forces in the enlargement of its terminals and the rearrangement of its tracks and laying out new engine houses and other things that would bring in revenue, the road would be very much better off. The chances of the road ever getting a cent out of the cost to make this valuation are very, very slim.

So much for valuation. As a real piece of engineering, — this is academic engineering we are hearing about to-night, — the chairman referred to my little speech last night. At New Haven there is a small railroad club. Last night Mr. Smith, superintendent of telegraph of the New Haven Road, read them a paper on railroad telegraphy and arranged a surprise for them. They didn't know that he had installed in the Hotel Garde a loud-speaking telephone, and that he had arranged with three speakers, including myself, to talk over the telephone from the South Station. That is another branch of engineering, and it is decidedly interesting, to say the very least.

Mr. Parker. — You say the results will be disappointing, and spoke of some of the statesmen who are advocating this. What do you say to Senator La Follette's statement that 70 per cent. of the railroads are over-capitalized?

Professor Cunningham. — The valuation will not show that. The forecast shows that the value of the roads, as a whole, is going to be in excess of their capitalization, as a whole. Of course there are exceptions, and it is the exceptional cases we hear the most about. The railroads are not over-capitalized, and that can be shown, I think, very clearly when we know that the capitalization of the average American railroad is something like $63 000 a mile, while in England it is $277 000, in Prussia $116 000, and in France something more than in Prussia. The American railroads are the lowest of any country in capitalization.

Mr. Parker. — You mean the reproduction value would be as great as the capitalization?

Professor Cunningham. — I think this whole question is an academic discussion that really will amount to very little. The question is, Is the amount of money represented by the securities in the property? In my opinion, it is going to be overwhelmingly demonstrated by the few valuations which are nearing completion that the capitalization of the roads which are valued are less than the value under any plan of valuation.

Mr. Parker. — I have gathered that, if the railroads would separate their enormous land holdings, the valuation would show a great deal less than their valuation. . . .

Professor Cunningham. — The Boston and Maine has no land holdings which amount to anything, but it is safe to say that its valuation will be very much in excess of capitalization. The capitalization of the Boston and Albany is fifty millions. I think that they will have little trouble in finding fifty millions between Boston and South Framingham.

Mr. Irwin.* — As Professor Cunningham says, we do not know how the results of this valuation work are to be used. However, the Valuation Act passed by Congress in 1913 very definitely requires the work to be done.

I am really more optimistic than Professor Cunningham is. In view of present conditions, I believe that the railroads will receive value for every dollar they are spending on the valuation.

* Assistant Valuation Engineer, Boston and Albany Railroad.

Professor Cunningham says he believes that the values in the railroads will more than cover all the securities that are outstanding. So do I, but the American public has to be shown that they will, and I believe that one great purpose of this valuation is to show that there is no further question about it.

Mr. Shepherd's paper is so clear and comprehensive that there is very little to be said regarding methods used in valuation work except as the work on other lines may differ from that on the Boston and Maine.

On the Boston and Albany, the field parties on cross-sectioning and track inventory work were made up mostly of men in the employ of the railroad, the Government merely having a recorder with each party. In this respect the organization differs from that on the Boston and Maine, where the Government furnished the party except the pilot, who was a railroad employee.

Our outside work on grading and track is practically completed at the present time. Before starting the work in the spring, the entire road was chained, and survey parties went ahead of the cross-section and track inventory parties, and maps were prepared for the use of the inventory parties. The work in general was done just as it has been done on the Boston and Maine.

The taking of wash borings for determining the depth of fill in soft places where settlement has occurred has been mentioned. The Boston and Albany had this work done by contract, a Government representative being continually with the outfit to check the results. This work was also valuable in determining the depth of fill in areas where the original surface could not be determined. The results obtained showed, as they did on the Boston and Maine, that the hidden values proven in this way fully warranted the cost of the work. However, the conditions will vary greatly on different roads.

The most interesting case on the Boston and Albany was at Richmond, Mass., west of Pittsfield, where the records showed that there had been difficulty in filling across a big swamp when the road was originally built in 1840, and where settlement has continued to the present time. In this case, with a visible height of embankment above the surface of the ground of only 18 ft., the total depth of the fill was shown to be 63 ft. As the bed of the swamp was composed of peat, the limits of the sand and gravel fill could readily be determined.

Our office work has differed somewhat from Mr. Shepherd's. Although we used office cars for the headquarters of the field parties and the care of maps and records required by them, our drafting and computing was all done in the Boston office.

In conclusion, I want to say that I consider Mr. Shepherd's paper to be a most valuable addition to valuation literature.

Mr. Hayes.*— I want to thank you all for this opportunity of hearing Mr. Shepherd's paper.

I have been with the men employed in inventorying the property of the Fitchburg Railroad during the greater part of the summer, and have noted the great care with which this valuation work was being done. It seems to me that when they get their work done we shall have a very remarkable record, one which has never been had before, of just what the railroads have, just the condition it is in, and just how much property there is in the railroad business. I differ from Professor Cunningham, as I feel that such a record will be of very considerable value, not only to the railroad but to the public.

There is just one thought that has occurred to me. Professor Cunningham says that this valuation is for the purpose of fixing the value of the railroad property. I do not look at it in that way. As I understand it, the order is to find out what it cost the railroads to create this property and also to find out what it would cost to recreate the property at the present time. What the value is, is another and a perplexing question, and I suppose that we shall not be able to know how to find what the value is until we have completed the valuation of practically all the railroads. Then we will know, I hope, by a process of elimination, whether there is to be more than one value of a property; I mean whether there is to be one fair value for rates and whether there is to be another fair value to be used in case of sale. We do not know whether the valuation was ordered by Congress for the purpose of finding a price to be used in case

* Engineer, 101 Milk Street, Boston.

of purchase by the Government, or of establishing a basis for fair charges for service, or simply to know whether the railroads of the country have been over-capitalized or not. At any rate, we will have all the information necessary. We will know what the railroads cost, we will know what it would cost to reproduce them; and between these figures a proper fair value can be found. I have the greatest confidence, from what I have seen of the thoroughness with which the work is being done, that this valuation will be of very considerable value to the country.

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PAPERS AND DISCUSSIONS

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# POWER ESTIMATES FROM STREAM FLOW AND RAINFALL DATA.

By Dana M. Wood,* Member Boston Society of Civil Engineers.

## SCOPE OF NOTES.†

The analysis of rainfall and run-off records and the making of estimates of available power and expected financial returns cover quite different lines of investigation, but they are so closely related that they must be considered together. The former considers the raw material and the latter the manufactured product.

In these notes we have not concerned ourselves with the intermediate steps, the tools and process of manufacture, except in knowing to what extent they affect the amount and cost of the output. In other words, we must know the amount of shrinkage which takes place in changing the raw material to the finished product, and its resultant effect upon cost. The determination of the amount of shrinkage which may be economically allowed is another problem, — that of design, — and in this study we are interested only in knowing whether this amount has been estimated to be 30 or 60 per cent. with a given development scheme.

Note. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before May 10, 1916, for publication in a subsequent number of the Journal.

* With Stone & Webster Engineering Corpn., Boston.

† An index of this paper is printed on pp. 119–120.

Assuming that the development scheme of an existing or contemplated plant has been planned along the most economical lines as regards first cost, a complete investigation of the power available at any water-power site resolves itself into the following general cases:

(*A*) A compilation of all available rainfall and run-off records applicable to the case under consideration.

(*B*) A study of their reliability.

(*C*) A determination of the most probable run-off for typical years at the given site.

(*D*) A brief study of the available market, primarily to determine probable load factors.

(*E*) Modification of flow estimates on account of available storage and pondage.

(*F*) Estimates of the power available.

(*G*) Corresponding financial returns for various operating conditions.

The ultimate purpose of any analysis of rainfall and run-off data is to determine the quantity and distribution of the stream flow available, which, in turn, offers the basis for estimates of

(1) The economical plant capacity.

(2) The maximum uniform load in kilowatts (or horsepower) which can be depended upon at all times in all years, and known as primary power.

(3) The length of time that other loads will be available, these loads varying between this primary power and the plant capacity, and being classed as "secondary power," using the latter term in its broader sense.

(4) The expected energy output in kilowatt (or horsepower) hours corresponding to these primary and secondary loads.

(5) The expected financial returns.

In case some form of relay power is available, other more or less complex estimates are required, such as that of the amount of auxiliary power needed to increase the water primary power to required or desirable higher amounts, times during typical years when it will be required to supplement the water, etc.

It is appreciated that no one simple method of analysis will give all of the desirable information in any given case, but it has seemed worth while to evolve a method that with one set of comparatively simple computations will give most of it, leaving only a few items for special investigation.

In choosing the methods to be used, it is important to remember that in most cases predictions or estimates are for the future and that they are based upon past records. Owing to unforeseen changes in regard to the load conditions, power rates, etc., departures from the expected occasionally result. The purpose of any careful estimate, however, is fulfilled generally if the order of magnitude of the development, both physical and financial, is indicated.

It is the purpose in these notes to mention briefly a number of methods used by engineers in attacking certain features of the general problem and to introduce for purposes of discussion some modifications of these methods.

## A. — RAINFALL AND RUN-OFF BASE DATA.

### Rainfall Data.

Practically all important precipitation records are obtained under the direction of the U. S. Weather Bureau, which has divided the country into districts and sections, according to geographical location. The statistics for the more important meteorological stations can be found in the "Monthly Weather Review." Statistics for many of the less important stations can be found only in the monthly summary reports issued by the various districts. A publication entitled, "The Climatological Data for the United States, by Sections," contains complete records at many stations up to 1908 and 1909. Complete bound records for all stations can usually be found in the larger district offices of the U. S. Weather Bureau.

Important additional data can often be found in publications by special commissions or bureaus, such as those issued by the New York State Water Supply Commission, Maine Water Storage Commission and others.

In the presentation of rainfall tables, it is the universal custom to obtain the average annual rainfall by totaling the average amounts for each month of record. It is desired to call attention to the fact that in many investigations this method may be misleading, as it gives too high results. A few months of excessive rainfall, for instance, will materially increase the monthly average, since their total will equal that of many very low months. It is suggested that a better method in some cases might be to tabulate the number of occurrences of various amounts of rainfall and to then obtain a mean for each month, adding these together as before, to obtain the yearly average. This suggestion is of course quite revolutionary.

## Run-off Data.

Run-off records at many localities can be found in the following publications, which are arranged in the order of their usefulness and dependability:

1. Water supply papers, U. S. Geological Survey, Water Resources Branch.
2. Reports by special state commissions and boards.
3. Flood elevations on many navigable rivers are published by the U. S. Weather Bureau.
4. Private records (not published).

Full information regarding standard field and office methods used in obtaining and compiling run-off data can be found in the following:

1. "River Discharge," by J. C. Hoyt and N. C. Grover; John Wiley & Sons.
2. Numerous publications of the U. S. Geological Survey, Water Resources Branch.

It is assumed in that which follows that all available records applying to a given case have been collected and compiled in the following standard form for each station:

1. General description of the river basin.
2. Description of the gaging station.
3. List of discharge measurements.
4. Station rating curve and table.
5. Tables of mean daily gage heights.
6. Tables of daily discharge estimates.
7. Monthly summary tables.

## B. — RELIABILITY OF RECORDS.

### Rainfall Records.

Practically all government records are taken by coöperative observers, who usually receive no recompense for their services. Generally, observations are made accurately and honestly, but at times they are not. The government bureau, owing to lack of appropriations, can exercise very little close supervision in the form of frequent personal visits to the observer, and there is no way of determining the reliability of the records other than through a personal knowledge of the conditions at the station under consideration.

In some cases the stations are well located, but in others the convenience of the observer has been consulted, to the detriment of the accuracy of the records.

Then, again, the standardized methods of to-day may in many cases be materially different and better than in the earlier records. This is of great importance in drawing conclusions from very long-term records.

As a check on the reliability of long-term records in New England, the following relations may be useful. Similar relations can profitably be determined for other sections of the country:

| | | |
|---|---|---|
| Rainfall in very driest year | = | 0.6 to 0.7 of average for long series of years. |
| Rainfall in ordinary dry year | = | 0.8 of average for long series of years. |
| Rainfall in wettest year | = | 1.3 to 1.5 of average for long series of years. |
| Rainfall in very driest year | = | 0.4 to 0.5 of that in very wettest year. |

### Run-off Records.

To determine the reliability of run-off records, it is customary to make comparisons between stations.

The commonly used unit of discharge is the "second-foot," an abbreviation for cubic feet per second, and equivalent to that quantity of water flowing in a stream one foot wide, uniformly one foot deep, at a velocity of one foot per second.

*Units of Comparison.*

Comparisons of *daily* run-off records show very considerable differences, even for neighboring stations, because of variations in precipitation in the respective watersheds, of control by existing power plants, and other reasons. It is preferable, therefore, to compare the average run-off for longer periods of time, and a month is the period frequently chosen for comparisons.

To eliminate the effect of the size of the watershed areas, it is customary to compare *unit* rather than total rates of flow, and the common unit is the "second-foot per square mile of watershed." In special cases the unit rate may be based upon the net land area, deducting that of the existing water surface areas comprised in the lakes and ponds in the basin.

The U. S. Geological Survey has recently inaugurated the practice of showing comparisons of the monthly average rates of flow in second-feet. Where this is done, the ratios of the drainage areas involved should first be determined as a guide to the normal ratios of discharge. All drainage area ratios should be less than unity, — that is, in their determination, the area of the upstream station, or the smaller watershed, should be used as the numerator.

*Comparison of Monthly Records.*

Natural or artificial causes entirely apart from errors in collecting and compiling stream flow data may make the ratio of monthly mean discharge *in second-feet* at two stations in the same basin depart widely from the ratio of drainage areas. The amount of probable departure depends primarily upon the magnitude of the ratio of the drainage areas. If the drainage area ratio is very small, little significance can be attached to a very wide departure in the monthly mean discharge ratios from the drainage area ratio. The important fact is that all second-foot discharge ratios between two stations should be *less than unity*, otherwise the records are in error.

The following statements apply only to dependent streams, that is, streams whose discharge in the numerator of the ratio is also included in the denominator.

1. In general, unless the discharge is controlled by artificial storage, the ratio of mean monthly discharge in second-feet should be lower than the drainage area ratio during the period when the streams are frozen; higher during the spring run-off; lower during the late summer and fall; higher during periods of high water and lower during periods of low water.

2. Ratios of unit run-off per square mile should be less than unity when the streams are frozen and during periods of low water, and greater than unity during periods of high water.

3. At certain times of the year there may be considerable departure from the above general statements, on account of the unequal distribution of precipitation and run-off. These inequalities are more evenly balanced over large areas than over small ones. For long periods, such as a year or more, the second-foot discharge ratio as a rule should be very nearly the same as the drainage area ratio, although there are many notable exceptions to this rule, particularly for drainage area ratios less than about 0.60.

Natural variations in conditions affecting run-off in adjacent independent areas are so great as easily to render unadjusted ratio comparisons of discharge of little value. When, however, the records at each station are reliable, it is often possible to establish some definite similarity or relation in run-off, as will be shown later.

*Application of General Principles as Broad Checks.*

In investigating apparent discrepancies in the monthly mean discharge ratios, consideration should be given to the relative amount of precipitation in the partial areas and also to the natural and artificial conditions which may possibly affect the discharge.

Ice and log jams below stations may, for instance, result in an estimate of the discharge which is altogether too high, owing to the resultant back-water conditions.

The records of discharge obtained at dams are usually not as satisfactory as records obtained at current meter stations, owing principally to the involved character of the determination of the discharge at any dam, which requires many assumptions and the use of hypothetical formulæ.

The ratio of the maximum to the minimum daily or momentary discharge will decrease as the size of the drainage area increases.

The larger the drainage area on a given river, the lower will be the unit run-off (in second-feet per square mile) for a short period of time. The reasons for this are that —

(1) Rainfall is unevenly distributed over a given basin, the total effect being less than if it had occurred uniformly.

(2) Rainfall usually (not always) increases with altitude.

(3) Heavy local rains near the lower station usually have a less total effect than if occurring at the upper because of the increase in ground storage capacity at the lower, due to the flattening out of the slopes, and to the change in character of the soil.

If two stations are within a few miles of one another, the second-foot coefficient of relation may vary from unity at low flows to the drainage area ratio at high rates of discharge.

In general, the yield of a large watershed is more steady and suffers less in drought than a small watershed.

## C. — DETERMINATION OF MOST PROBABLE RUN-OFF FOR TYPICAL YEARS AT GIVEN SITE.

The selection of the method to use in determining the probable run-off for various periods for typical years at a given site will depend largely upon the character of the available records, which will usually come under one of the following general classifications:

1. Ample long-term run-off records at the site under consideration.

2. Short-term run-off records at the given site and long-term records at other points in the same or neighboring watersheds of similar characteristics.

3. No run-off records at the particular site, but numerous records at stations in the same or neighboring watersheds of similar characteristics.

4. No run-off, but ample rainfall records within reasonable distance.

In the second and third cases the records at distant sites are reduced to estimates of run-off at the given site. This requires comparisons between the various records, and the determination of average relations. It is obvious that in such cases estimates for the locality under consideration are more or less approximate.

In the fourth case, dependence must be placed entirely upon rainfall records. Many attempts have been made in the past to apply percentage relations of run-off to rainfall as determined by actual records in more or less distant watersheds of similar characteristics. Recently, more precise methods have been suggested.

## C-1. — Ample Run-off Records at Given Site.

*Methods of Obtaining an Average Year's Run-off.*

1. A little-used method of determining the run-off during an average year is to prepare a table with rates of flow, either in second-feet or second-feet per square mile, arranged in order of years and calendar months, and to compute the average discharge for each calendar month.

This method invariably gives too high results. To show an extreme case of this, assume that in a period of one year, the rates of run-off for three months were very high, while for the remaining nine months they were very low. The arithmetical average in this case would be very much higher than the true mean, which should take into account the number of occurrences of different rates of flow. It is the number of occurrences rather than the average rate of flow which the investigator desires to obtain.

2. A second method very commonly used is to prepare a table with the monthly flow records arranged in order of years, but with the months arranged in order of dryness. The "driest months" are averaged, then the "second driest months," etc., and a computed average year thus obtained.

While more conservative than the first method, this also gives too high results.

3. A still more conservative method is to arrange the flow

records by months in order of dryness, regardless of the year in which they occurred, and to then compute the run-off for an average year in a manner similar to the previous two cases. For example, if a fifteen-year record is being used, the fifteen driest months found in the entire period are first averaged, then the fifteen second driest, etc.

This, or as modified below in No. 7, is probably the most satisfactory method to use when only monthly flow records are available and more refinement is not desirable.

4. The next possible refinement in method which some engineers have resorted to is similar to the three preceding, but consists in analyzing average *weekly* instead of monthly flow records.

5. We now come to the method of analyzing run-off records most commonly used to-day. It is really an adaptation of the second method described above, and probably has the greatest range of usefulness and interpretation of any of the methods.

The discharges or corresponding gage heights are tabulated in order of magnitude, and opposite each is entered for each year of record the total number of days when the flow or gage height does not exceed the given amount. By adding these totals of days for any number of years and averaging, the run-off for an average year is obtained.

It should be noted that, in contrast to most of the methods given above, the average year computed thus contains both the extreme minimum and maximum daily rates of flow, the former being extremely useful in relay power and storage studies.

6. A modification of the second and fifth methods described consists in arranging the rates of discharge in order of magnitude for each year, averaging first the maxima, then the next lower set, and so on down to the minima.

7. When average monthly or weekly flow records are being used, the principles indicated in method No. 5 can still be used, — that is, a table can be prepared showing the number of times various rates of flow have occurred during the period of record. These results, when expressed in percentages, will typify an average year, including the extreme maximum and minimum rates of flow.

*Duration Curves of Flows — Average Year.*

The results of all of the methods mentioned can and preferably should be shown in the form of duration curves of flow. Ordinarily, the results are plotted with rates of discharge as ordinates and time in months, weeks or days as abscissæ. For facility in making power estimates, it is convenient also to indicate a secondary time scale in per cent. These curves are frequently referred to as "per cent. of time — flow curves," or "duration curves."

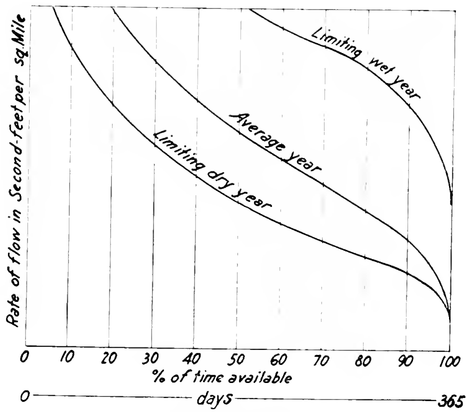


FIG. 1. DURATION OF FLOW CURVES.
Base flow data corrected for storage, when available.

*Other Types of Years.*

After obtaining the estimated run-off in an average year, averages can be made of such records as fall below this, thereby obtaining what may be called an ordinary dry year.

In some cases, as when estimates are being made of the maximum annual output required from a relay plant under the worst flow conditions that may be expected, a theoretical flow record should be determined for what is known as a "limiting dry year." This is obtained by computing a composite year, consisting of the minimum records for varying lengths of time, taken from the actual records regardless of the year in which they occurred.

If monthly records are being used, this theoretical dry year is obtained by taking the twelve driest months shown by the records as arranged in accordance with one of the three first methods described. Weekly records can be similarly treated.

In case daily records are being analyzed, this limiting year may be obtained by taking the maximum number of days in any year not exceeding given rates of discharge.

Another method sometimes used in obtaining this limiting dry year run-off is to take from the records, regardless of the actual year in which they occurred, the average flow for the minimum day, week, two weeks, three weeks, two months, etc., and to plot a duration curve of flow from this data.

Using methods similar to the above, a " limiting wet year " can be determined if it is so desired. This type of year is of less usefulness than the dry year, but is occasionally of importance in cases of considerable loss in power from back-water conditions.

Records for actual years which coincide for a major part of the year with the above computed types are sometimes used, in preference to a theoretically computed record. Some computation is necessary, however, to determine the order of magnitude of the record for an actual year.

The " wettest year " has also arbitrarily been defined by one author as that year in which the run-off for the five driest months was the greatest; and correspondingly, the " driest year " as the year in which the flow for the five driest months was the least.*

### C-2. — Short-Term Run-off Records at the Site, Modified by Records Elsewhere.

*Method of Drainage Area Ratios.*

In reducing records at one locality to estimated records at another, the most common assumption is that the unit run-off

* Sargent, E. H., " Long-Term Variations in Stream Flow, Croton and Hudson Rivers," *Engineering News*, Vol. 72, p. 1119 (December 3, 1914).

per square mile at the two points considered is the same, — or, in other words, that the rate of flow in second-feet varies directly as the size of the watershed. This is approximately true for long periods of time when the physical and climatological conditions for each watershed are quite similar. For the short periods this relation rarely, if ever, holds.

This method of reduction is easy of application, and one that is frequently adopted when rough estimates at the site to be utilized are all that is desired. In those cases where there are no records available at the locality in question, it is usually the only practical method.

*Hazen Method.*

Another method of analysis, practical in the latter case, has been suggested by Mr. Allen Hazen in a paper entitled "Storage to be Provided in Impounding Reservoirs for Municipal Water Supply."* This method is complicated, and frequently requires considerable time for its solution.

*Comparison of Integrated Unit Flows.*

It frequently happens that there are relatively short-term records available at the site to be developed, while much longer records may exist at another locality in the same or neighboring basins. After the records to be utilized have been compared in a broad way, as indicated in previous sections, and after they have been found reliable, it becomes necessary to ascertain if there is any fixed relation between the site to be developed and the auxiliary stations.

To do this it is usually advisable, first, to plot a diagram of integrated yearly unit flows per square mile at one station as ordinates and the corresponding integrated flows at the second station as abscissæ. By "integrated flows" is meant a mass curve of unit rates, — i. e., the accumulative rates period by period. The same scale should ordinarily be used for both ordinates and abscissæ.

If the yearly integrated flows are found to lie at varying distances from any possible average slope line, it then becomes

* Trans. Am. Soc. C. E., Vol. LXXVII, 1915, p. 1539.

necessary to repeat the operation by months. In other words, the accumulative rates for all of the Januarys are plotted in one diagram, for all the Februarys in another, etc.

It is frequently found that on the monthly basis it is still impossible to draw a graphical slope line which will truly average most of the points. This indicates that the coefficient of relation between stations varies with the seasons rather than by months. Therefore, the next step would be to repeat the above process, this time by first plotting the accumulated January plus February run-offs, then February plus March run-offs, March plus April run-offs, etc. This method can be still further carried to a tri-monthly relation, if necessary.

The above method, either worked out on the basis of single months, successive two-month or three-month periods, or a year, will ultimately indicate some period in which all of the plotted points will lie fairly close to an average slope line. The slope of this line determines the coefficient to be applied to the records for the corresponding period at either of the stations to obtain the other. It is then possible to assume that similar seasonal coefficients apply to the earlier of the long-term records, and thus to extend the short-term records to the same periods as covered by the long.

### C-3. — No Run-off Records at Given Site, but Available Elsewhere.

In this case, usually the only available method is that first described in the preceding section as method of "drainage area ratios." In some cases, the results thus obtained can be modified by a judicious use of precipitation data, as indicated in the following section.

### C-4. — Use of Precipitation Data.

(Especially applicable when no run-off records are available.)

It is possible to estimate approximately the run-off from a given stream if the evaporation (used in its broader sense, including seepage, transpiration of vegetation, etc.) over the entire basin can be determined, by deducting the latter from the average precipitation. Many attempts have been made to determine a percentage relation between rainfall, evaporation and run-off. Owing to the many factors which influence the amount of evaporation losses, and the uncertainty in their exact determination, together with the many known inaccuracies in the collection of rainfall data, this method of estimating stream flow should be used only as a last resort.

There are three general cases when a study of rainfall records may prove of some benefit.

(1) When no run-off records are available within any reasonable distance.

(2) When run-off records are available at only one or two distant points in the same or similar basins.

(3) When it is uncertain whether the available run-off records cover average, dry or other types of years.

While percentage relations between run-off and rainfall fluctuate through wide limits, it is sometimes necessary as a last resort to assume approximate values for typical years in a restricted locality.

The following rule was presented by Mr. C. E. Grunsky:*

"The percentage of the seasonal (12 months) rainfall which appears in the stream as run-off, when the rain is less than 50 in., is equal to the number of inches of rain. When the seasonal rain is in excess of 50 in., 25 in. thereof goes to the ground (evaporates, etc.), the remainder is the run-off."

That is, if $P$ = percentage, $R$ = rainfall and $Q$ = run-off,

When $R < 50''$, $P = R$ and $Q = PR$.
When $R > 50''$, $Q = R - 25''$.

There are many exceptions to this rule, when used promiscuously, so that it should be used with caution, especially since it was developed for western conditions. No modification has been attempted by the writer as applicable to New England conditions. For example, records of run-off and rainfall of the Housatonic River at Falls Village, Conn., both prove and disprove it (rainfall in this case may not necessarily be the average

* Proc. Am. Soc. C. E., May, 1915, p. 1281.

for the basin above, as there are few rainfall records available in the actual basin):

| | Rainfall. Ins. | Ratio of Run-off to Rainfall. Actual. Per Cent. | Grunsky. Per Cent. |
|---|---|---|---|
| 1913 | 49.06 | 49.3 | 49.0 |
| 1914 | 32.32* | 63.0 | 32.3 |

*Estimates of Run-off from Rainfall.*

In deducing run-off estimates from rainfall records it is first necessary to make a careful examination of all rainfall records in the basin above the site under consideration and determine a fair value for the average, maximum and minimum yearly amounts.

A study of the annual relations between run-off and rainfall † in other not too distant basins will determine the percentage relations for similar types of years which must be assumed as applicable to the given basin. The monthly distribution of run-off in these other distant basins will serve as an index of that most probable in the given basin.

The above method is approximate. In drawing conclusions from rainfall records it must be remembered that before averages of a number of stations can be used, either the period of time used should be the same for all, or an estimate should be made for the longer period covered, using the shorter term records as a basis. Methods for doing this are well known and will not be further treated here.‡

Those who have made any considerable study of the question of the percentage relation of run-off to rainfall will have noticed that it may vary materially in two years having practically the same total precipitation. Besides the question of its distribution, probably the factor principally responsible for this variation is the relative height of the ground water table. To form some idea of the amount added or drawn from this

* Lowest rainfall on record in twenty-six years.

† See "Relation of Rainfall to Run-off," by Geo. W. Rafter, U. S. Geol. Survey, Water Supply Paper No. 80.

Also, "Computing Run-off from Rainfall and Other Physical Data," by Adolph F. Meyer, Proc. Am. Soc. C. E., March, 1915, with subsequent discussions.

‡ See Progress Report, 1908, New York State Water Supply Commission, p. 143.

ground-water storage, it is necessary to collect such data as may be available regarding the general changes in height of the water surface in existing domestic wells, marshes, etc. Usually it is very difficult to find any reliable information of this sort, and the problem is rendered the more uncertain. This suggests the advisability of some government or state department collecting a certain amount of hydrographic data along these lines.

*Rainfall as Modifying Distant Run-off Records.*

When run-off records are available at one point in a basin, while estimates are desired at a quite distant site, a study of available rainfall data may serve as a basis of modifying the known run-off records to suit the new locality.

Let us assume two sites, A and B, the former being the station further upstream.

The first step consists in obtaining the mean effective elevations of the basin above the upper and lower sites and between them. The total average annual precipitation on each area may be assumed to be proportional to the average elevation of the basin above each site, or —

(mean elevation above $A$) $\times$ (its drainage area in sq. mi.) $= a$
(mean elevation $A$ to $B$) $\times$ (its drainage area in sq. mi.) $= b$
(mean elevation above $B$) $\times$ (its drainage area in sq. mi.) $= a+b$.

The above indicates that the total annual precipitation on the area above $A$ is $\frac{a}{a+b} = X\%$ of the total at $B$.

This is $\frac{X\%}{\text{D.A. at } A \div \text{D.A. at } B} = Y\%$ of the direct ratios of the drainage areas; i.e., the precipitation per unit of area of watershed above $A$ is $Y\%$ of that of the entire basin above $B$ (including that above $A$).

If it is now assumed that the run-off varies directly with the precipitation, $X\%$ of the run-off at $B$ would be coming from $A$. In general, however, the ratio of run-off to rainfall increases with the rainfall, and rainfall increases with altitude, so that something more than $X\%$ may be expected to come from above $A$.

If $P_h$ is the average precipitation at the highest station in the basin and $P_l$ is that at the lowest, then

$$\frac{P_h - P_l}{\text{Elevation of } h - \text{Elevation of } l}$$

which indicates the inches increase (or decrease) per foot of increased elevation; or if the two elevations were divided by 100, the increase per 100 ft., a better unit, is indicated. The above percentage relations can now be modified by this last result, if the precision of the base data warrants this refinement.

*Ascertaining Types of Years.*

One use made of precipitation data in nearly every investigation is to determine the character both of the individual and groups of years covered by available run-off records, — whether the period considered is an average one, an extremely dry or wet one, or of some intermediate type.

This naturally introduces such questions as the "cycles of rainfall" * and allied problems, which cannot be discussed further at this time.

## D. — STUDY OF THE AVAILABLE MARKET.

In so far as the line of investigation covered by these notes is concerned, a study of the available market is necessary to determine —

(1) The most probable daily, monthly and yearly load factors.

(2) The average price expected for the general classes of power.

Any field survey of the market should include many other facts not required for the above purposes. As a guide to the essentials of such a survey, the following outline is submitted:

A complete field survey of the available market should furnish the following information:

1. Information from a canvass of present power users.

* See "Cycles of Rainfall," by D. M. Wood, Stone & Webster Public Service Journal, September, 1913.

(1) Name of concern.
(2) Class of work.
(3) Kind of power.
(4) Cost of fuel.
(5) Age and condition of plant.
(6) Horse-power, installed and used.
(7) Hours of operation.
(8) Daily and yearly load factor.
(9) Will contract for current (yes or no).
(10) Determine (*a*) estimated distribution max. demand factor (ratio max. station load to connected load).
(*b*) estimated yearly load factor (based on 8 760 hours per year) at generating station.

2. Classification of above information.

A. Total horse-power in use
(1) Now.
(2) Five years ago.
(3) Ten years ago.
(4) Fifteen years ago.

B. Total horse-power used for
(1) Lighting.
(2) Industrial.
(3) Traction.

C. Total industrial power of
(1) 10-hour duty.
(2) 12-hour duty.
(3) 18-hour duty.
(4) 20-hour duty.
(5) 24-hour duty.
(6) Intermittent duty.

D. Tentative agreements for power service.
(1) Concern.
(2) Horse-power.
(3) Hours of service.
(4) Rates, dollars per horse-power per year.
(5) Annual value at 100% load.

E. Probable cost of present power to each consumer.

3. Competition in the proposed field.

(1) Existing steam or other plants.
(2) Prevailing cost of steam or other power analyzed.

4. Study of bank clearings, post-office receipts and population census, serving as guides as to rate of growth of the community. Amount of building construction during recent years as shown by building permits.

A study of the results of such a market survey are of course essential in determining the probable percentage utilization of the water power available during the early years in the history of a new development covering the period of building up the load. This naturally includes also the tentative planning for additional units, including questions of additional energy available, additional steam requirements, etc.

## Load Factor.

As stated above, one of the essential results of the market investigation is a determination of the probable load factors at which the new plant will run.

"Load factor" as used in these notes is the ratio of the average to the maximum power during a certain period of time, as a day, month or year.

In the majority of investigations only the broadest conclusions can be drawn regarding load factor at the time of making power estimates and determining plant capacities. For this reason it is usually a refinement to assume the shape of the load curve, although it is absolutely necessary to assume some percentage as applicable, — as 40 or 50 per cent.

When this is the case, in computing power from stream flow, it is sufficiently accurate to assume full load conditions for a part of the day corresponding to the load factor, and to assume no load during the balance of the day. For instance, a 50 per cent. load factor is equivalent to a full load for twelve hours, a 40 per cent. load factor for 9.6 hours, etc.

In a few special cases there is enough certainty at an early stage of the investigation regarding the character of the power market to warrant assuming the shape of the load curves. This case will be discussed later under "power estimates."

In connection with load factor, it is essential also to determine the diversity factor of the system load. Diversity factor is the ratio of the sum of the maximum power demands of the subdivisions of any system or part of a system to the maximum demand of the whole system or part of the system under consideration, measured at the point of supply. The more non-coincident these peak services are, the greater will be the diversity factor.

## E. — MODIFICATION DUE TO STORAGE AND PONDAGE.

### Definitions.

"Pondage" is used in these notes to mean that water storage capacity available daily or weekly to equalize the variations in the power load. On the other hand, "storage" means that capacity which may be available to increase the extremely low flows for several days, weeks, months or even years. Another way of expressing this is to say that storage is the retention of flood-water for use during times of scarcity, while pondage is the retention of the flow of a stream during hours of light load and for use during hours of heavy load.

The terms "pondage" and "storage" are more or less analogous if a period of time longer than a day is taken. If we adhere strictly to our definitions, however, no confusion should arise from the term used.

It can readily be seen from the above that the study of pondage and storage must follow and not precede at least that portion of the market investigation which will definitely settle questions pertaining to the character of the future loads, such as most probable daily, monthly and yearly load factors, etc.

### Storage Studies.

The next step in the general problem of making power estimates is to modify the natural rates of flow determined for typical years by the use of any new storage, the benefits of which are not already included in the flow data. Usually these studies are made on a monthly (sometimes weekly) basis. Numerous methods commonly used in making storage studies are so well known that only brief reference to the most general tabular and graphical methods will be made in these notes.

*Tabular Computations.*

Some engineers make tabular computations, with columns headed something as follows:

1. Year and month, in calendar order.

2. Natural run-off at the site under investigation, in second-feet or a unit rate.

3. Amount drawn from the given storage reservoir.

4. Amount added to the given storage reservoir.

5. Amount in the given storage reservoir at the end of the month. (In these last three columns the available storage is usually expressed in an equivalent rate for one month.)

6. Regulated run-off at given site. It is necessary to assume a regulated run-off for the apparent longest and worst drought in the period covered by the records and then to find the correct flow by " cut and try " computations.

*Mass Curves.*

Probably the most commonly used method of analysis is that known as the " mass curve." The method consists in adding up the totals of the monthly run-off from month to month (can be applied to other periods than month) for the whole period under consideration, then plotting the successive steps of accretion of the mass as an irregular line or mass curve.

Any desired rate of draft may then be assumed and its successive sums plotted to the same scale. If the rate is uniform, this draft curve forms a straight inclined line which is made to start coincident with some point or summit on the mass curve, and serves to show by the vertical distance between the two curves at any point of time the volume of storage that would have been required to maintain the given rate of flow up to that time.

*Characteristic Flow Curves.*

A " characteristic " flow curve shows the relation between the regulated rate of flow at any particular point on a stream and the amount of storage required to maintain that rate of flow, this relation being determined from the " mass curve."

*References.*

More complete details of the above may be found in the following references:

1. New York State Water Supply Commission Reports, especially Fourth Annual Report (1909), pp. 360–364, covering —

(1) Mass curve for river regulation problems.
(2) Mass curve for pondage problems.
(3) Mass curve for auxiliary power problems.
(4) Mass curve for flood regulation problems.
(5) Conversion curves.
(6) Characteristic curves.

2. Maine State Water Storage Commission Reports, 1910–13.

3. U. S. Geological Survey, Water Supply Papers Nos. 198, 279 and others.

4. Numerous standard text-books.

## Pondage.

It is next necessary to further modify the natural rates of flow for typical years as modified by new storage available, by the use of pondage.

The amount of pondage required in any given case depends entirely upon the load factor or may limit the size of plant for any predetermined load factor (that is, the ratio of the average to the maximum momentary peak load). Whether it is the daily load factor or the load factor for some longer period of time which determines the amount of pondage required, depends upon the conditions in the investigation in progress.

1. A conservative method of studying the benefits of pondage is to assume the plant fully loaded for the number of hours determined by multiplying the daily load factor in per cent. by 24, and to assume the plant shut down during the remainder of the day. Reference to Fig. 2 will amplify the following useful relations:

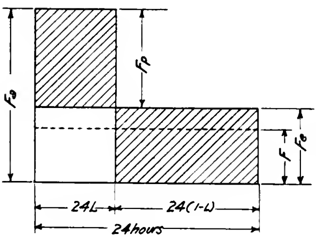


Fig. 2.

Let $F$ = any average 24-hr. rate of flow, in sec.-ft.

$F_e$ = 24-hr. rate of flow which is completely equalized by pondage, in sec.-ft.

$F_a$ = average of flow available during the working hours, in sec.-ft.

$F_p$ = average rate of flow during the working hours supplied from pondage, in sec.-ft.

$C$ = pond capacity in cu. ft.

$P$ = equivalent average 24-hr. rate of flow in sec.-ft. which the pond would yield with no flow into the pond.

$L$ = load factor, expressed decimally.

$$\text{Then } P = \frac{C}{86\,400}; \qquad (1)$$

$$F_e = \frac{P}{1-L}. \qquad (2)$$

Case I. When $F < F_e$,

$$F_a = \frac{F}{L}; \qquad (3)$$

$$F_p = F\frac{(1-L)}{L}. \qquad (4)$$

Case II. When $F = F_e$,

$$F_a = \frac{F}{L} = \frac{F_e}{L}; \qquad (5)$$

$$F_p = F\frac{(1-L)}{L} = F_e\frac{(1-L)}{L} = \frac{P}{L}. \qquad (6)$$

Case III. When $F > F_e$,

$$F_a = F + F_p = F + F_e\frac{(1-L)}{L}. \qquad (7)$$

($F_p$ = same as in Case II.)

The above equations will indicate greater pondage than is actually required in those cases where there is intermittent drafting and ponding during the period. On the other hand, they are exact for those cases where the draft from pondage is continuous, even if at verying rates, after it once commences, — that is, when the stream flow into the pond is continuously less than the flow from the pond.

2. Mr. Charles T. Main * uses in water-power studies for

* Journal of N. E. Water Works Association, Vol. 21, p. 214.

mill operation what he terms ratios or "multipliers." Water is used, say, for ten hours a day and six days a week. If the pondage is of sufficient capacity to enable storing the entire fourteen hours' night flow and using it during the remaining ten hours, and if no water is wasted, the ratio of the flow used in ten hours to the 24-hr. rate is 2.4, and 2.4 times the 24-hr. rate of flow would be used during the ten working hours. If the entire flow from Saturday night until Monday morning could be stored, the ratio would become 2.8. He usually allows a leakage factor of 10 per cent., reducing the last ratio to 2.52. When the pond cannot hold all of the flow during the time when the plant is not running, the ratio will be less than 2.52.

Formulæ and diagrams can be worked out to make these computations less laborious.

With a series of mills, some with small ponds enjoying the benefits of larger ones above, if it takes one hour for the water to get down from the upper to the lower, the multiplier at the lower would be reduced 10%; for 2 hours, 20%, etc.

3. Another method of studying questions of pondage is indicated in the first reference under the previous heading of "Storage — *References*."

## F. — ESTIMATES OF POWER AVAILABLE.

### Economical Plant Capacity.

There are many methods in use for determining the economical development point in a water-power proposition, some of them of questionable value. A brief mention of a number of these may prove of interest.

1. Referring to the first three methods described in Section C-1, some engineers have assumed that the discharge indicated by the third or fourth wettest month of the computed average year corresponds to the economical development point. Other engineers have used other months down to the sixth driest.

2. Another method seen by the author in special report work consists in selecting the year containing the longest and severest drought and assuming that the discharge in the fourth

or fifth wettest month in that year corresponds to the economical development.

3. In March, 1910, a committee of the New England Water Works Association made the statement * that " a yearly average of approximately one tenth of one horse-power (or 0.075 kw.) per square mile of tributary watershed per foot of fall (which corresponds to a maximum 24-hr. flow or development of water of about 1.4 cu. ft. per second per square mile of watershed, and a maximum available 24-hr. net power of 0.12 horse-power per foot of fall per square mile of watershed) may generally be obtained economically, and a correspondingly greater rate of output if the power be used for less than twenty-four hours per day, and sufficient pondage be available to make such concentrated use of the water possible."

4. The real economical plant capacity appears to the writer to be dependent not only upon the results of the analysis of stream flow base data, but also upon operating load factors and financial considerations, including construction costs and operating revenues.

It is hardly necessary to state that the above methods of estimating capacity have been the result of attempts by various engineers to formulate a rule which would be more or less of an average covering all developed plants known to them.

The proper method would seem to be one of " cut and try," assuming at least three different capacities covering all reasonable operating conditions, computing the available output for each, estimating costs to obtain fixed and operating charges and assuming average prices for the output to enable computing most probable revenues. By plotting these results, it will become evident at what capacity the net revenue and percentage return on the investment is the greatest. In other words, the economical capacity is dependent upon the results obtained by the complete investigation covering all probable operating conditions.

Considering the latitude in selection of methods, depending upon the judgment and experience of the investigator, together with the variations in flow in the estimated type of year accord-

* Journal of New England Water Works Association, Vol. 24, p. 8 (March, 1910).

ing to which method is used in analyzing the base data, it can easily be seen through what a wide range the estimates of economical capacity for the same development by several engineers will vary.

It is desirable to call attention to the fact that, unless special operating conditions exist, resulting from a tie-in with other power plants, the maximum actual peak on a hydroelectric plant will not exceed from 80 per cent. to 90 per cent. of the installed capacity. Allowances should be made for this when computing either the economical capacity or the power available from a given installation.

In that which follows, methods of estimating the power available for any given plant capacity will first be discussed, followed by a few brief remarks regarding the financial considerations referred to above.

### Estimates of Power and Energy.

Briefly reviewing the steps leading up to the computations of power and energy, it is first necessary to collect and analyze the base data, obtaining an estimate of the run-off at a given site for the type of year most pertinent to the case under consideration. In that which follows, it is assumed that the records have been arranged in the form of a "per cent. of time-flow curve, corrected for storage," although the method to be described can likewise be applied with some minor modifications to any actual hydrograph.

In that which follows, a general method is offered for purposes of discussion, involving a minimum of laborious computations and yet giving a considerable amount of the information always necessary in the consideration of plans for developing or enlarging a water-power plant. Some problems cannot be answered by this method, and these must necessarily be left for a special solution.

The most probable yearly, monthly and daily load factor to be expected should next be decided upon. Ordinarily, the expected yearly load factor should be used as a basis for the computations to be described, but in view of possible departures from the expected, it is better practice to compute for a range in yearly load factor. In that which follows, 30%, 40% and 50% yearly load factors are assumed for purposes of discussion.

In case of relay power studies, monthly and daily load factors to be expected are of importance as affecting the seasonal distributions of the load between the plants, but in case they are used, some utilization factor should be applied to obtain yearly estimates. This will be mentioned again later.

We are now ready to consider in detail the various steps in the computations of power and energy available with a given development scheme. A few necessary assumptions will be mentioned in their proper places.

*General Method of Computing.*

1. For ease in tabulating, it is suggested that computations should be based upon per cent. of time, by 5% intervals, commencing with the minimum flow. The first column in the tabulation, then, should perhaps be headed "per cent. of time available," starting at 100% and decreasing by 5% intervals.

2. The 24-hr. rate of flow as corrected for storage and corresponding to each 5% interval should next be tabulated.

3. In the case assumed for discussion, the next three columns should have the general heading "Flow available at given load factor," and a column should be allotted to each case, — 30%, 40% and 50% load factor.

The broad assumption is here made as described under a previous section, "Pondage," that the plant is assumed to be fully loaded during a number of hours corresponding to the load factor and idle during the remaining hours. Formulæ for computing the flow are indicated in the same section on page 99.

It should be noted that in assuming that the daily load factor is the same as the yearly, the question of water utilization during the year has been taken care of to a certain extent.

4. The next problem is to compute the "net head available," and this usually consists of three steps. The net head available is determined by the pond elevations above the dam, the losses through the water passages and the elevations of the tailwater.

In general studies prior to construction, unless actual relations can be determined, it is usually assumed that the tailwater elevation will stand at the same height for a given rate of flow after construction as it does before.

Usually it is sufficiently accurate to assume the losses through the water passages as a constant throughout the computations.

Granting the last two assumptions, it is possible to draft a curve of relation between head and flow after construction, *exclusive* of draw-down of pond for equalizing daily (or other) load factor.

The final net head available can next be computed as a separate step by subtracting the average loss of head due to draw-down of the pond, whenever the rates of flow are less than that required for the full plant capacity.

For any point on the duration of flow curve (or 5% interval in the table under construction), the amount of water required from the pond during a 24-hr. period for equalizing any given load factor is the difference between the flow available at any load factor and the natural flow. To obtain the maximum draw-down of the pond during this 24-hr. period, the draw-down in feet corresponding to the total pondage available is multiplied by the ratio of the required to the total pondage expressed either as a volume or as a rate of flow, properly modified by load factor.

On the assumption that the draft from the pond is uniform (i.e., neglecting the shape of the daily load curve as previously mentioned) and that the depletion curve for the pond is a straight line, the average draw-down will be one half of the maximum. For ordinary conditions, these two assumptions lead to no material error.

5. Either from the known characteristics and efficiency of the wheel and generator actually to be installed, or from general relations from manufacturers' catalogs, the power corresponding to the flow available at various load factors and net heads can next be computed, in either horse-power or kilowatts, regardless of the limitations due to any specific number of units. In other words, the power actually available in the river as a source is thus computed for the desired range of load factors. Other losses, such as for excitation, should also be included.

6. A new table should next be prepared with "per cent. of time available," "corresponding 24-hr. rates of flow," and "net head available" columns, starting from 0% of time and increasing by 5% increments. In other words, this table commences with the high-water end of the duration curve, and the net head, of course, cannot include any draw-down of pond. From

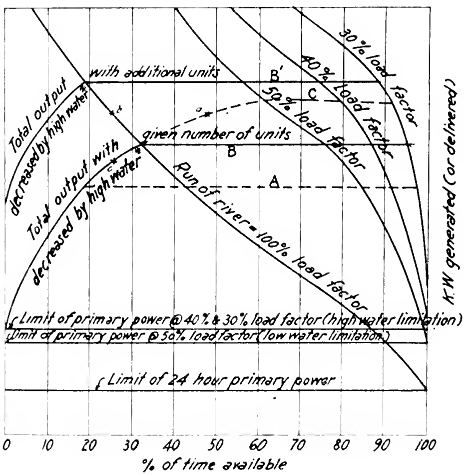


Fig. 3

POWER CURVES

\+ Decrease due to loss in head.

the known characteristics of the wheel and generator, the total available output for any given number of units can be computed.

*Diagrams.*

*Power Curves.*—The results of the preceding computations can be plotted in the form of "power curves," with power plotted as ordinates and per cent. of time available as abscissæ. Fig. 3 has been prepared to illustrate diagrammatically the general case discussed.

The results obtained under item 5 preceding are first plotted, the resulting curves representing the power available at varying load factors (30%, 40%, 50% and 100% here assumed) regardless of any limitations due to a specific number of units.

The results obtained under item 6 preceding are next plotted, indicating the total available capacity or output in kilowatts that could be obtained with a specific number of units. This curve starts at 0% of time (i.e., at the high-water side of the power curves).

At extreme high-water times (0% of time) the net head and consequently the output is at a minimum, due to backwater conditions. As the flow decreases, the head and output increase until a point is reached when all of the 24-hr. rate of flow is consumed by the wheels, i.e., at the intersection of output curve from given number of units with the run-of-river or 100% load factor curve, unless limited to a lesser capacity by the number and size of the units installed. From zero per cent. of time to that per cent. corresponding to this intersection point, the machines can be run at full water capacity for twenty-four hours a day, and the total energy possible to be obtained is only limited by the actual load conditions expected (load factor).

As the flow decreases still further, it is necessary to make up from pondage the deficit required by the wheel capacity. From the previously mentioned intersection with the run-of-river power curve, the total capacity available from a specific number of turbines will follow a horizontal line (or line of constant power "B" in the diagram) until it in turn intersects the "power available in the river at a given load factor" curve. For the per cent. of time covered by this horizontal line the machines can be run at full capacity, but for a number of hours gradually decreasing from twenty-four to that corresponding to the given load factor.

From the latter intersection, the total capacity of all of the wheels can no longer be maintained by pondage, and the total power available from a given number of units will fall back along the given load factor curve, ending at 100% of the time. For this latter portion of the time, the units can be operated for a given number of hours each day corresponding to the load factor, but with decreasing total power output.

In reality, the line " B " is not horizontal, but slopes slightly downward to the right. As more and more pondage is used, the average net head available decreases somewhat, due to draw-down of pond, with resulting changes in efficiency relations and slight decrease in power available.

The available plant capacity cannot continue to increase beyond the 100% water load factor curve, as to line " C " in the diagram. To show that this is true, consider any point (*a*) in this line " C." It corresponds in kilowatts to (*b*) on the 100% run-of-river curve, having practically the same relations between flow, head and power. Obviously the total plant output possible at (*b*) is indicated by the limiting output curve directly beneath it on the same per cent. of the time line at (*c*).

In the case of Fig. 3 as drawn, the primary power available at 100% and 50% load factors is determined by low-water limitations. On the other hand, it should be noted that the low-water limitations for a 40% load factor are higher than the high-water limitations, and that for all load factors less than about 45%, the limitation of primary power in the figure as drawn is determined by the power available at times of extreme flood (zero per cent. of time). These relations apply only to the diagram under discussion and do not necessarily apply to other cases.

*Summary Tables and Curves.*—Much interesting data can be taken from these curves, and presented in other summary tables or curves.

The primary plant (or delivered) load corresponding to any load factor can easily be obtained, and the corresponding yearly energy output in kilowatt (or horse-power) hours estimated (Kw. Hr. = Kw. × 8 760 × load factor).

The secondary power (or delivered) load for varying lengths of time can be obtained as follows: Slide the horizontal per cent. of time scale upward to successive points where the distance between the curve of " total output at high water " and a given load factor curve will equal 95% of the time, 90%, 85%, etc., noting the successive differences in load between the successive time intervals. The yearly energy output corresponding to these successive differences can easily be obtained in a manner similar to the primary output, adding the new factor to the previous equation, " times average per cent. of time."

The same results can be obtained by the use of a planimeter, if so desired.

Power curves as shown are extremely useful in studying the effect of successive blocks of power sold at different load factors, and afford an easy means of determining the balance of power left at any given load factor.

The data obtained from such power curves can easily be plotted in a series of useful diagrams. For example, one set might show primary and secondary loads available with varying load factors; another set, the corresponding yearly energy output.

Numerous useful relation curves can be prepared while compiling the power table; for example, relation between net head and switchboard or delivered loads, relation of pond to tailwater level for varying conditions, etc.

*Approximate Method.*

In general cases it is customary to make approximate power computations as follows:

$$(1)\ \text{Hp. (turbine)} = \frac{Q \times h}{11};$$

$$(2)\ \text{Hp. (electrical)} = \frac{Q \times h}{12};$$

$$(3)\ \text{Kw.} = \frac{Q \times h}{16};$$

when $Q$ = rate of flow available.
$h$ = net head available.
Hp. = horse-power generated at switchboard.
Kw. = kilowatts generated at switchboard.

The reduction factor in equation (1) is based upon an average turbine efficiency of 80%, while that in equation (2) assumes an average plant efficiency of 73.3%. The reduction factor in equation (3) is obtained by multiplying equation (2) by $\frac{3}{4}$, the approximate relation of kilowatts to horse-power.

The over-all plant efficiency may vary through a wide range during any single day. In one case the writer has seen this vary from 48% to 86%, with an average of 74%, or practically that obtained by equation (2).

To obtain delivered wholesale power at high tension a liberal allowance for all transmission losses, depending upon length of line, size, etc., is from 10 to 15%, so that the above results should still further be reduced. If an 87½% transmission efficiency is assumed as a fair average to be used, the over-all system efficiency would equal 64%.

It is often advisable to install one unit of capacity about equal to the ordinary minimum stream flow. Where larger units are installed, or when the loads are such that they operate through a wide range of gate opening, the question of lost efficiency due to light loads on the unit may become important, and some further allowance should be made in the power estimates.

*Utilization Factor.*

The term "utilization factor" has been coined to define that coefficient by which the total energy is reduced, to make an allowance for changing efficiencies due to the character of the load, actual daily variations in load factor from that assumed, leakage and waste in operation, percentage of peak to installed capacity, etc. This utilization factor is applied to all rates of flow, modified by the use of the pond, up to that corresponding to the full station capacity. Its amount should be higher if computations are being made on the basis of an assumed yearly load factor than if on the basis of an assumed monthly load factor.

Some engineers allow a factor of safety in the original flow records by deducting, say, 10 per cent. from available stream flow before making the estimates, this to cover losses in operation and leakage. It is a question of individual judgment whether such allowance should be made, especially in view of the fact that some conservatism has already been used in the

### Illustrative Case of Approximate Method of Computing Power and Energy at a Given Plant.

| Per Cent. of Time Available. | Average Year (1900–1914). | | | Available Kw. in River at 35% Load Factor. | Available Kw. Hr. | |
|---|---|---|---|---|---|---|
| | 24-hour Rate of Flow in Sec.-ft. | Sec.-ft. Available at 35% Load Factor. | Differences. Col. (3). | | Successive. | Total. |
| Col. (1). | (2) | (3) | (4) | (5) | (6) | (7) |
| 100 | 916 | 2 620 | | 12 430 | | 32 400 000 |
| | | | 950 | | 11 450 000 | |
| 95 | 1 250 | 3 570 | | 16 970 | | 43 850 000 |
| | | | 520 | | 5 950 000 | |
| 90 | 1 490 | 4 090 | | 19 400 | | 49 800 000 |
| | | | 220 | | 2 380 000 | |
| 85 | 1 710 | 4 310 | | 20 500 | | 52 180 000 |
| | | | 160 | | 1 637 000 | |
| 80 | 1 870 | 4 470 | | 21 200 | | 53 817 000 |
| | | | 240 | | 2 303 000 | |
| 75 | 2 110 | 4 710 | | 22 400 | | 56 120 000 |
| | | | 380 | | 3 410 000 | |
| 70 | 2 490 | 5 090 | | 24 150 | | 59 530 000 |
| (66.5%) | | | (170) | (25 000) | 1 510 000 | |
| 65 | 2 740 | 5 340 | | 25 350 | | 61 040 000 |
| 60 | 2 890 | 5 490 | . . . | . . . | . . . . . | . . . . . |

*Base data.*

Plant capacity = 25 000 kw.

Net available head = 76 ft. (variations in head neglected).

Pondage available = 78 750 000 cu. ft. for 5-ft. draft.

Load factor = 35%.

*Explanatory of table* (slide rule computations).

Col. (3) — Pond will completely equalize all daily flows at 35% load factor up to 1 400 sec.-ft.

Above 1 400 sec.-ft., $F_a = F + 2\,600$ sec.-ft.

Col. (4) — Ordinarily omitted, but included here for clearness.

Col. (5) — $\text{Kw.} = \dfrac{F \times 76}{16} = 4.75\,F.$

Col. (6) — Kw.Hr. (successive) =

$$\underbrace{4.75}_{\text{Power constant}} \times F \times \underbrace{8\,760}_{\text{Hours per year.}} \times \underbrace{35\%}_{\text{Load factor.}} \times \underbrace{85\%}_{\text{Utilization.}} \times \text{(av. per cent. of time available).}$$

arrangement of the base data. It seems the better practice to include this in the utilization factor, as noted in the previous paragraph.

*Refinement of Computations.*

The question may well be asked as to what degree of precision is warranted in the computations. The writer has always believed that usually it is good practice to carry out the computations of power and energy to as much refinement as can be obtained from a slide rule, then rounding up the final estimates to good even figures to eliminate "bargain house prices," as one engineer has so aptly called those power estimates carried out to four, five or even more significant figures. In other words, it seems preferable to carry out the assumptions and computations to greater refinement than is warranted in the final answer, to prevent "creeping errors" from showing up in the estimates finally presented. As stated before, estimates for the future are being based upon past records, and in many cases only the broadest prediction can be made regarding such features as load factor, etc. After once making a good guess as to these factors, it would seem desirable to stick as closely as possible to it in the detail estimates. Much the same method is always followed in cost estimating.

## Characteristic Load Curves.

In the foregoing, only broad assumptions were made as to the effect of load factor on the power available from the stream. In some cases, more refinement is desirable.

An ingenious method of studying the typical load curve and the resulting limits of plant capacity that may be expected was presented before the American Institute of Electrical Engineers by Mr. Cary T. Hutchinson.*

He first deduces a duration curve of flow by days as previously described, and from that obtains a "per cent. deficiency curve" where per cent. deficiencies are plotted as ordinates

* "The Economical Capacity of a Combined Hydro-electric and Steam Power Plant," by Cary T. Hutchinson, American Institute Electrical Engineers, March, 1914.

and flows in second-feet or second-feet per square mile are plotted as abscissæ. He next suggests a study of actual load curves, developing what he calls a "characteristic load curve."

The first step consists in deriving a representative daily load curve, departing from the usual procedure by plotting per

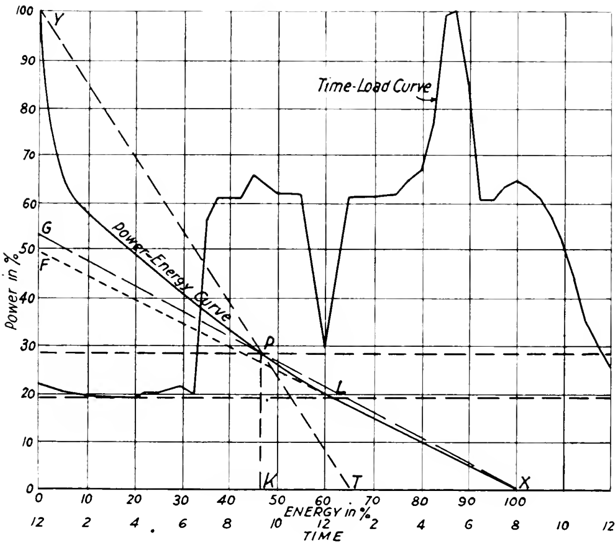


Fig. 4

CHARACTERISTIC LOAD CURVES

cent. of power against time. (See accompanying Fig. 4, representing a combined light, traction and power load.) This is done to reduce loads covering a wide range in peak to some common basis of comparison, just as the hydraulic curves are often plotted in second-feet per square mile.

From this load curve he derives a power-energy curve, or, as he calls it, a "per cent.-load" curve. The ordinates are per cent. of power and the abscissæ per cent. of "peak-energy," using the same length of scale for both. This curve is obtained by drawing successive horizontal lines and determining the per cent. of the load lying above it. For example, the abscissa *OK* of the point *P* gives the percentage of the total energy lying above the horizontal line through *P*, or "peak-energy," while the ordinate *KP* is a measure of the "base load."

This curve consists of a straight line from *X* up to the point *L* on the horizontal line through the minimum power and a curve tangent to it. From this power-energy curve, several interesting properties are found:

1. If the straight line *XL* is extended to intercept the *Y* axis at the point *F*, then *OF* indicates the load factor corresponding to the curve.

2. A straight line from *Y* through any point *P* will intercept the *X* axis at *T*, and the load factor of the peak load above *P* is equal to total load factor *OF* multiplied by *OT*.

3. A line drawn from *X* through the point *P* intersects the *Y* axis at the point *G*, and the load factor of the base load is *OF* divided by *OG*.

The above enables one to determine at once the capacity of the steam plant required to meet any assumed conditions of the hydraulic development, or, for that matter, any ratio of minimum to rated stream flow.

The following may serve as an interesting guide to the possible combinations of cases likely to arise, although lack of space prevents a detail discussion in these notes:

A. Peak less than water plant capacity.
B. Peak equal to water plant capacity.
C. Peak greater than water plant capacity.
  1. Minimum water day.
  2. Medium stage, flow less than full plant capacity.
  3. Flood stages, unlimited water.
    (1) Ample pondage.
    (2) Restricted pondage.
    (3) No pondage.
    (4) Effect of storage.
    (5) Interference by power users above.

Cases A and C are usual, while B is theoretical and rarely found in practice. With ample pondage, the hydraulic plant should carry the peak until the flow increases sufficiently to enable it to carry, in cases A and B, the entire load, or, in case C, the base load.

With no or restricted pondage, the hydraulic plant should, of course, be operated as a base load plant, carrying as much of the load as possible up to its full capacity.

## Auxiliary Power Studies.

It will be evident from what has preceded that the duration curve method of arranging stream flow data with resultant power curves offers excellent opportunity for making studies of relay or auxiliary power problems. If the power for an average year is determined as previously described, the extreme minimum power is also indicated, so that either the required relay capacity to make up a given deficit can be determined at a glance, or the benefits of a definite amount of relay capacity ascertained. (See Fig. 3.) The output in an average year is figured by integrating the area between the line representing total combined water and relay capacity and the flow-power curves at any given load factor.

One problem of particular importance regarding relay power which cannot be obtained from the methods given in the foregoing is the actual calendar time during a given year when the relay power might be needed according to past records. Another is the variations in load factor on the water and auxiliary plants.

If the shape of the load curve is assumed, the most economical division of power between and corresponding load factors of the relay and water-power plants can be determined either by "cut-and-try" methods or as indicated under "characteristic load curves."

In many power studies it is approximately correct to assume that the system load factor applies to the individual plants, thus simplifying the computations. It is obvious that steam plant capacities under this assumption will be higher (and hence on the safe side) with a normal load curve than if it is assumed that the hydraulic plant carries the peak load and the relay plant the base during low-water periods, and the reverse during high water.

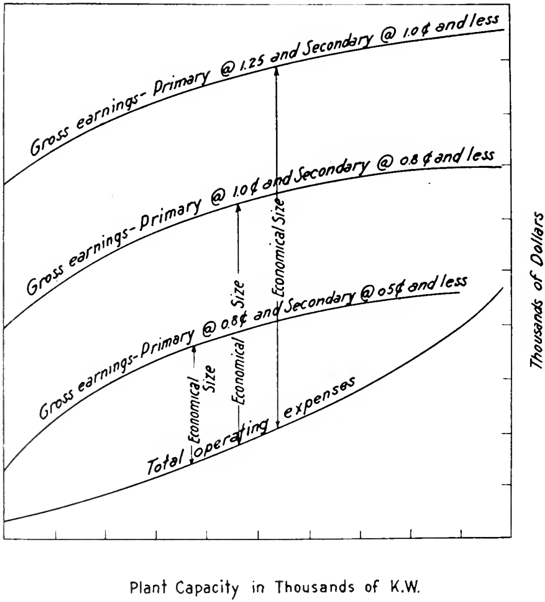


Fig. 5
NET RETURNS, NO RELAY POWER

G. — FINANCIAL CONSIDERATIONS.

The economical plant capacity for both water and auxiliary plants is not only dependent upon the stream flow and resultant power available, considered in connection with the size and character of the market, but also upon the gross and net income which may be expected from the sale of the commodity power. Accompanying Figs. 5 and 6 indicate two methods of obtaining the most economical water plant capacity, from a study of the power available, with resulting gross receipts, and a determination of the probable operating expenses. That capacity is the most economical at which the net percentage return on the investment is the greatest.

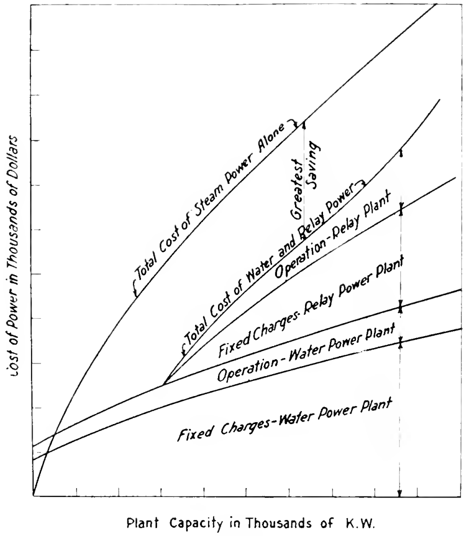


Fig.6
NET RETURNS WITH RELAY POWER

Further discussion of this subject seems unnecessary, although there are several other interesting methods, all with the same object in view as the above.

## CONCLUSION.

The purpose of these notes has been twofold: (1) to show the need of a careful analysis of stream flow records for power estimates, and (2) to indicate several methods of conducting office investigations. Considerable information condensed into the foregoing will be found scattered through many publications, some of which are referred to. It is hoped that these notes will prove a time-saver for both those who desire a broad outline of the problems involved and those who desire references to the more important publications covering the subject.

Many important references have necessarily been omitted, but the following have been found useful in compiling the foregoing, in addition to those given throughout the text, and contain suggestions for further enlargement of the subject.

1. Mead, Daniel W. Water Power Engineering. McGraw Publishing Co., 1907, 1908 and 1915. (This book is the most comprehensive and thorough that the writer has reviewed.)
2. Main, Chas. T. Computation of the Values of Water Powers and the Damages Caused by the Diversion of Water Used for Power. Journal of the New England Water Works Association, Vol. 21, p. 214 (September, 1907).
3. Frizell, Joseph P. Water Power. John Wiley & Sons, 1907.
4. Raymond, W. G. Power Capacity of a Running Stream without Storage. Journal of the New England Water Works Association, Vol. 22, p. 184 (June, 1908).
5. Stevens, J. C. Length of Time Required to Determine Rainfall or Stream Flow with a Given Percentage of Error. Engineering News, Vol. 60, p. 309 (September 17, 1908).
6. Chandler, C. E. Stream Flow Data from a Water-Power Standpoint. Journal of the New England Water Works Association, Vol. 21, p. 464 (December, 1907), and Vol. 22, p. 409 (September, 1908).
7. Running, T. R. Filling and Emptying Reservoirs. Engineering Record, Vol. 69, p. 67 (January 17, 1914).

## INDEX.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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# PAPERS AND DISCUSSIONS



## CLEANING OUT LOCK GATE TRACKWAYS AT THE CHARLES RIVER DAM.

BY EDWARD C. SHERMAN,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

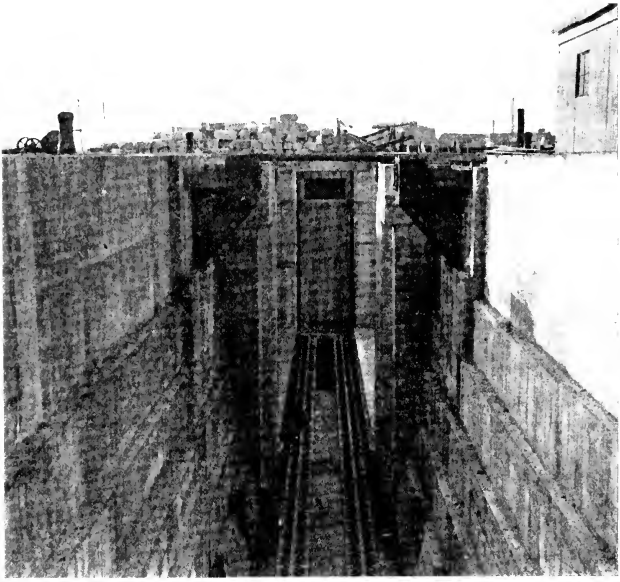
DURING the construction of the shut-off dam, by which the tidal flow in the Charles River was stopped so that an earth dam could be built, the rolling-caisson gates of the lock were left open in order to afford additional waterway, as the velocity of the current made the work in the river exceedingly difficult. When the shut-off dam was completed and it was desired to close the gates of the lock, it was found that the trackways, or recesses in the floor, were filled with sand, deposited there by the water, so that the gates could not be moved. The deposit in the upper trackway was partly removed by jetting, as the velocity of the current made it very difficult for a diver to work.

The apparatus for jetting consisted of a $2\frac{1}{2}$-in. wrought-iron pipe, with a header at the bottom end. In the header were set six or eight nozzles of smaller pipe, flattened at the end to give long, narrow openings, and aimed downwards about 30 degrees from the horizontal. This apparatus was hung over the front end of the upper lock gate so as to bring the nozzles a little below the tops of the rails on which the gate runs. Connection was then made with the fire pump of a towboat, and water was forced out of the nozzles at a high velocity. Coincidentally, the lock gate was moved forward a few inches at a time.

Progress was slow and finally ceased when about two thirds

* Of Rourke & Sherman, Consulting Engineers, Boston.

of the distance across the lock had been traversed, as stones and other débris which had been buried in the sand accumulated ahead of the gate, the jets being able only to move them forward and not to raise them high enough so that they would be swept away by the river current. It was then necessary to resort to a



LOCK GATE TRACKWAY AT CHARLES RIVER DAM WHICH WAS FILLED WITH SAND TO LEVEL OF LOCK FLOOR.

diver, who completed the work, taking out the remaining material a bucketful at a time. The diver was assisted by a man who worked in the air chamber which surrounds the gate truck, and which is reached by means of an air lock in the gate. As soon as the upper gate was closed there was slack water in the lock, and the work of cleaning out the lower gate trackway was an easy matter for the diver.

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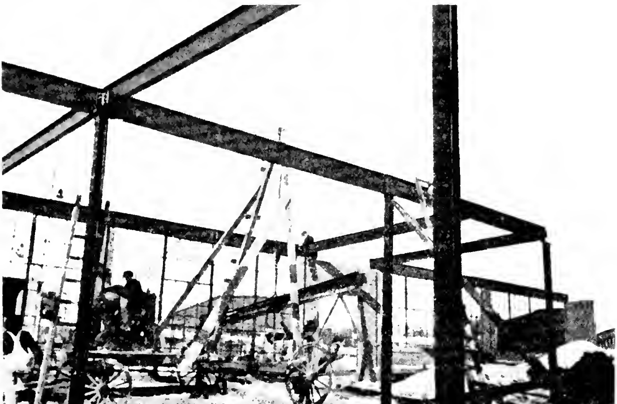
# PAPERS AND DISCUSSIONS



## A "MONKEY CART."

By E. F. Rockwood,* Member Boston Society of Civil Engineers.

In the spring of 1913, the New England Concrete Construction Company was building a weave shed of mill construction



approximately 120 ft. by 420 ft. The first floor of this weave shed was of hard pine plank carried by steel beams and girders

* Chief Engineer, New England Concrete Construction Company, Boston.

which rested on brick piers. There were eighty bays, each 24 ft. by 26 ft. The girders were two 18-in., 55-lb. I's, 24 ft. long, and the beams were 15-in., 42-lb. I's of 26-ft. span and 8 ft. center to center. The tops of the beams came about 8 ft. 0 ins. above the ground, which had been filled with cinders to an approximately level grade. There were about 240 tons of steel in the floor. This was bought direct from the mill.

Bids were obtained from several steel erectors for the erection of this material, but the contractors thought the bids excessive and decided to do the work themselves. They took two pairs of wheels and connected them into a cart with a framework platform. On the rear wheels having a 12-ft. axle was mounted an "A" frame which could be tipped down when necessary to go under work already erected. On the front was mounted a hand winch. The cart was fitted with shafts, but it was found cheaper to use laborers, rather than horses to move the cart. The accompanying illustration shows the cart, which the superintendent of the mill dubbed "the monkey cart." The contractors made a substantial saving over the bids given them for erecting the steel.

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# ADDRESS AT THE ANNUAL MEETING.

(March 15, 1916.)

By Charles R. Gow, President, Boston Society of Civil Engineers.

It is sometimes interesting, as a subject of reflection, to compare achieved results with original expectations, and the outcome of such cogitation is often disappointing in effect.

In reviewing the work of our Society for the year now drawing to a close, I must confess that the unaccomplished tasks appear, by comparison, to be more impressive in character and in number than do the actual attainments realized.

That there still remains an abundant supply of promising suggestions for the further improvement and perfection of our organization I can readily attest, and for the purpose of recording some impressions of this nature which come to mind, I am prompted to refer rather briefly to certain features affecting the operation of our affairs which might well be the subject of additional consideration and discussion.

My observations have led me always to believe that the chief aim of a society of this character should be to procure the freest possible interchange of knowledge, opinions and ideas among its members. This may be accomplished in at least two ways, — by means of written papers, formally or informally presented and subsequently published with such discussions as they elicit; or by means of social intercourse among the members, thus affording opportunity for verbal discussions of specific problems and topics. The exchange of personal experiences thus resulting is bound to prove invaluable to the participants.

It cannot be said that either of these methods has yet been developed to a satisfactory degree in the administration of our Society functions.

With a membership of approximately one thousand engineers, representing as it does every branch of the profession, there is bound to exist a collective fund of engineering information and experience which, if it could be made mutually available, would without question result in a wonderful advancement of our organization and of the profession as a whole.

With an occasional notable exception, it has not been the general practice among our members to give sufficiently of time and ability to render the service which the interests of the Society demands of them if this, its most important feature, is to be adequately developed and extended.

It is undoubtedly true that those members who are best qualified to contribute such information are often so preoccupied by reason of business demands as to render duties of this nature a serious burden. Nevertheless, it is to this source the profession must look for assistance if advancement is to continue, and it should be accepted as an obligation morally imposed, that even at a considerable sacrifice, members are individually responsible for the general propagation of engineering information and knowledge.

Regarding the possibilities for disseminating such knowledge through the medium of social intercourse, it is to be noted that, thanks to the very efficient and energetic work of the past two years on the part of the Committee on Social Activities, and especially of its most capable and enthusiastic chairman, Mr. E. M. Blake, our members have enjoyed the privilege of "rubbing elbows" with their fellows frequently and establishing a more intimate familiarity with them than has heretofore been possible. There can be little question of the genuine advantages of a social, educational and business nature which accrue to those who accept the opportunities thus afforded to extend acquaintanceship among their fellow-engineers.

The average engineer is not a good "mixer," as the term is generally understood, even among his associates, and it is indeed unfortunate for the engineering profession that this is so. It is difficult to determine the cause of this seeming deficiency which so many times appears to operate as a handicap, not only upon the individual but also upon engineers collectively. There appears to exist some phase in the development of the technically trained mind which produces a serious and somewhat reticent trend of thought and action. It was for the purpose of breaking down in a measure this tendency toward reserve that the Society introduced the practice of holding frequent pre-meeting dinners, and in addition to afford members facilities for individual discussions and intercourse which is impossible at formal meetings. I feel thoroughly convinced that this policy on the part of our Society has brought valuable results, and there is ample evidence of increased interest on the part of our members and a general improvement in Society spirit.

Not at least until engineers as a body have learned fully to appreciate the qualities of each other may we expect the general public to become impressed with their attributes.

In other words, while the engineering profession is concerned with the reason for the seemingly low estimate which the public in general sometimes places upon engineering advice, we overlook the fact that our own members frequently manifest a surprising lack of confidence in the opinions of their associates on common subjects of engineering discourse. If, therefore, we are ever to expect a respectful recognition on the part of the public of the right of engineers to solve engineering problems, there must first come some indication of substantial unanimity among the members of the profession itself as to common engineering questions. I contend that this result can only be brought about through a thorough discussion between engineers of their many problems, aided by a presentation of the combined experience of all individuals who are in a position to contribute.

This is not the first time that this subject has been called to your attention by a retiring president, and I trust that its principles may be restated at frequent intervals until such time as a majority of our members accept its importance as an issue.

Closely related to the preceding subject is that of the necessity for mutual toleration by our members of the opinions of their fellows. Without this attitude of mind it will be useless to expect coördination of thought and action among engineers. If, in place of cynical criticism of that which appears erroneous, useless or absurd in the arguments of our contemporaries, we search for the thread of truth, which almost invariably can be discerned if we seek it, and if we then submit to temperate and patient argumentative discussion our differing points of view, it will usually be found possible to arrive eventually at a point where conflicting beliefs may be more or less reconciled to the advantage of the participants.

Is not this the spirit which engineers should manifest if they sincerely desire to elevate their profession above the level of an individual competitive struggle for existence? I would ask our members seriously to consider whether each is contributing his share of effort in these directions, and whether they may not in fact be denying themselves benefits in the nature of wisdom and knowledge which unknown to them may exist in the reasonings of their fellow-workers whose opinions they disdain.

The rapid advancement in the sciences during recent years, the increased demand for technical skill in promoting the industries of a prosperous and growing nation, and the consequent wide diversity of effort into which the engineer has been called, have resulted in a strong tendency towards specialization on the part of the individual and a grouping into classes according to some particular line of endeavor or interest. This situation has resulted practically in a changed conception of the significance of the title of civil engineer. Nevertheless, few engineering projects of magnitude are executed to-day which do not require the combined services of men representing several if not most of the scientific callings, and so there is now apparent a more or less genuine recognition of the necessity for regrouping the diversified branches of the technical professions under a common leadership, because it is becoming obvious that, despite the apparent fundamental differences in the individual trend of thought and activities, the accomplishment of the final objective is dependent not upon one but upon a proper combination of many different lines of effort. Thus in the conduct of such enterprises as the construction of the Panama Canal, the great New York Water Supply System and the several subway enterprises for our large cities, we observe the surveyor, the draftsman, the structural designer, the electrical expert, the mechanical adept, the architect, the geologist, the chemist, the construction supervisor, and last but not least the contractor, — all working shoulder to shoulder, each contributing his special qualifications in a common cause, and under the direction and leadership of the chief engineer whose function it is to coördinate and harmonize the several abilities of his subordinates, to the end that the completed structure may reflect in its perfection of detail the combined wisdom, judgment and forethought of every branch of the profession.

In recognition of this principle, our Society has already taken steps looking to a more universal intercourse with other closely allied societies. Arrangements have been effected whereby a joint standing committee, comprised of nominees from our Society, and members similarly appointed from the local sections of the mechanical and electrical societies, will coöperate for the purpose of promoting a closer relationship between the three bodies and for devising means which will permit joint action in many of our activities.

It is to be hoped that this movement for the unification of engineers and engineering will continue to grow until the artificial barriers which have been allowed to separate our organizations in the past will be largely obliterated.

Much has been said in recent times concerning the desirability of engineers and engineering societies participating individually or collectively in attempts to influence or direct public affairs, and in a minor way our Society has taken some steps in this direction by the creation of a legislative committee whose function it is to observe attempted legislation on questions affecting engineering and to bring to the Society's attention unwise or inimical proposals for changes in law. In addition, representatives of our Society have been assigned at times to confer with and advise public boards, at their request, on matters of a technical nature. Undoubtedly much more can be accomplished along these lines to the advantage both of the general public and ourselves.

It has been urged at times that the Society should be made a factor in the community for the exercise of a certain measure of control or direction over administrative affairs of a public character so far as such matters are of an engineering nature or affect the profession or its work.

There probably never was a time in the history of our nation when there was greater need than at present for a wise and judicious oversight of the detailed actions of our governmental representatives; but the need which exists is for constructive assistance rather than for destructive criticism. There is already a great surplus of voluntary advisers who apparently seek to usurp the administrative functions of our several appointive and elective officials, leaving to those parties only the responsibility for such failures as may ensue. This I contend is an interference with good government and not an assistance. The need rather is for responsible bodies in the several communities, composed of individuals who from their nature and position command the confidence and respect of a majority of good citizens, who will analyze in a purely scientific, impartial and dispassionate manner such public acts and contemplated actions as they may by knowledge and experience be qualified to pass judgment upon, and will render their decisions in accordance with the actual facts, ascertained only after an exhaustive consideration of all the evidence available, regardless of prevailing prejudice, personal effect or political consideration; who will strongly defend public officials against irresponsible criticism whenever they are found to be right, even though such officials may otherwise be lacking in popular favor; who are capable of looking on matters with a broad perspective, and who are willing even to suffer personal loss if the contemplated act is for the good of the greater number of people.

I must confess that this outline of requisites presupposes an ideality not usually realized in present-day activities; but I will contend that if such attributes exist in the membership of any organization it may be expected to prevail among those composed of engineers. It is possible, therefore, that such a field of usefulness may be open to our Society, but such a departure should, in my opinion, be made with extreme caution.

When we have arrived at a position which warrants assurance that a majority of our members are constituted mentally and morally so as to guarantee immunity from the danger of personal bias or attempted individual aggrandizement; when we display a disposition always to accord full credit to its proper source, even when by so doing it may be necessary to reward those whom personally we dislike; when we appear disposed to sink our own interests and welfare into obscurity and stand for a given principle, at a personal sacrifice; and when we are able to brush aside all outward impressions of an indefinite and inconclusive character and form our judgment upon ascertained facts only, — then may we feel justified in interfering with administrative matters of a public or semi-public nature for the benefit of the community at large.

In the meantime, there is much useful work of a public character to which we may, if we wish, contribute. Our membership should be made available at all times to such public officials and commissions as may require expert opinions or scientific determination of facts.

Complicated questions are constantly arising in almost infinite variety for consideration and solution by public boards and officials. It is reasonable to assume that no individual, or single group of individuals can be presumed to possess the requisite diversity of knowledge to solve correctly all such problems without special outside assistance. So far as these questions may relate to technical subjects, there would seem to be no sound reason why the combined wisdom of our membership should not be put at the public's disposal, and it should become the common practice of governmental administrators to call upon this or other organizations especially qualified by education and experience to advise upon specific matters, for such expert analysis as the occasion demands.

This service should be rendered without money compensation, and solely for the good of the community. I do not wish to be understood as advocating that such service should be made to surplant the paid engineering departments of our several public administrative divisions. On the contrary, the aim should be to strengthen the efficiency of those departments by removing uncertainties and reducing the possibility of error. Here again good judgment will be required in the determination of the nature of the service which properly can be rendered without conflicting with the ethics of our profession. It would, for example, create a somewhat delicate situation if a committee of our Society were called upon to review the acts of a fellow-engineer. Under such circumstances probably nothing further than a clear presentation and analysis of the facts in issue could with propriety be embraced in any formal report, leaving the conclusions to the responsible parties. Under somewhat different circumstances, however, it might be possible to accompany such a report with definite recommendations.

An opportunity for public service of vast national importance is presented by recent agitations for the establishment of volunteer engineering corps throughout the country which would cooperate with the army engineers in planning national defenses and in preparing to execute such plans in case of emergency. Here there is offered a practical suggestion possessing great possibilities which can and should appeal to every engineer who styles himself a patriot. The organization within our ranks of a volunteer engineers corps will, without doubt, reflect in a practical way the value of our Society in a public as well as engineering sense.

Our membership has not changed materially since a year ago, at which time a marked increase was noted. I would recommend that serious attention be given to the question of the desirability of encouraging further increase beyond the natural additions which come from voluntary applications. A further substantial increase in our numbers is not in any way essential to the Society's welfare, and it is possible that it might prove detrimental. Quality of membership is far more important for the continued advancement and prosperity of our Society than is quantity. If our membership is of a character which commands the respect and attention of the profession at large, there need be no apprehension as to the future of our numbers. A membership that is drafted is less likely to be appreciative of the honor than one which is attracted by the superiority of personnel and the general excellence of professional results attained.

I suggest, therefore, that from this time consideration be given to plans for attracting new members by means of an established higher standard and broadened activities and that a more careful discrimination than now prevails be applied in the case of future applicants.

The Society is extremely fortunate in possessing ample financial resources from which to meet its current obligations, together with a rapidly growing surplus. This condition denotes a healthy state of our business affairs, and one which it is to be hoped will continue in the future.

Having established this favorable situation it would be most unfortunate for the continued welfare of the Society were we even for a single year to permit an expenditure in excess of income unless for an exceptional or unusual purpose. However, it appears, on the other hand, to be at least debatable whether any desirable activity which might tend to promote the Society's advancement should be ignored, sacrificed or curtailed for the sole purpose of increasing the amount of idle funds, which have now reached the total of $37 475 and which are growing yearly at an accelerated rate. Financial considerations which govern the actions of individuals or business enterprises may have little bearing upon the economic treatment of an organization such as ours.

It will be possible by a somewhat more liberal policy toward appropriations to create new activities which may greatly enhance the interest of our members and the importance of the Society. Should not considerations of this nature precede the desire for accumulation of finances for a vague, uncertain or indefinite future purpose?

I wish to impress upon you my thorough conviction that although there is undoubtedly much room for improvement in some of our Society affairs, we nevertheless are in a position to congratulate ourselves upon our splendid present standing and brilliant future prospects. Our general condition was never more promising than at present, and with a proper degree of loyalty, interest and progressiveness on the part of our members we may look for continued improvement and increasing importance in the community.

In conclusion, I wish to express my sincere thanks to those who have held me in sufficient esteem to honor me with the position of president during the past year, a privilege which I have keenly enjoyed and which I deeply appreciate. It will always be my earnest endeavor to continue to work for the welfare of the Society in the future as in the past, with the feeling that what is good for the engineering profession as a whole is also of advantage directly or indirectly to me as an individual member thereof.

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# THE SPILLWAYS OF THE PANAMA CANAL.

By Edward C. Sherman,* Member Boston Society of Civil Engineers.

(Presented February 16, 1916.)

The adoption of the high-level type of canal at Panama, with the consequent impounding by earth dams of large quantities of water in lakes which are essentially enormous storage reservoirs, necessitated regulation by masonry spillways of very considerable capacities at Gatun and at Miraflores.

## Gatun Spillway.

The lake formed by the great dam at Gatun, with surface at 85 ft. above sea level, has an area of about 168 sq. miles and receives the discharge of the Chagres, the Trinidad and the Gatun rivers, draining a watershed of 1 320 sq. miles. While the Isthmus of Panama is not subject to violent storms accompanied by heavy rains, the ordinary precipitation of the rainy season frequently causes great freshets in the rivers.† Records

† Trans. Am. Soc. C. E., Vol. LXVII, p. 112.

Note. Some parts of this paper and some of the illustrations relating to the design of the spillways were included in a paper presented before the International Engineering Congress in San Francisco in September, 1915.

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the Journal.

* Of Rourke & Sherman, Consulting Engineers, Boston. Formerly Designing Engineer, Isthmian Canal Commission.

of the discharge of the Chagres at Bohio have been kept for many years, the engineers of the French canal company having secured invaluable run-off data, and from more recent observations it has been determined that the discharge of the combined streams, at Gatun, is about 1.62 times that of the Chagres at Bohio.

From the available data, it appeared that the maximum rates of discharge at Gatun which should be considered in designing the spillway were as follows:

| | Sec.-Ft. |
|---|---|
| Maximum momentary rate | 183 000 |
| Maximum rate for 33 hours | 137 500 |
| Maximum rate for 48 hours | 120 000 |

The area of the lake at its normal level is so great that, with a spillway discharging 120 000 sec.-ft., an inflow amounting to 183 000 sec.-ft. would cause the surface to rise only one foot in twenty hours, and an inflow of 137 500 sec.-ft., lasting thirty-three hours, would cause it to rise only 0.46 ft. in all.

On account of the possibility of the occurrence of a freshet exceeding in duration and rate of discharge any of which there is record, it was determined to provide a spillway capacity of 140 000 sec.-ft., with the lake at its normal level of 85 ft. above sea level. The designs of the lock walls and gates were based on the assumption that the lake level would seldom be permitted to rise more than 2 ft. above normal, to elevation 87, and, as a simple overfall dam without regulating gates would have to be about 3 miles long to discharge 140 000 sec.-ft. without exceeding a depth of 2 ft. on its crest, it was decided to construct the dam with its crest below the normal lake level and to hold back the water by means of steel sluice gates of the Stoney type. This permitted the construction of a dam of reasonable length which would give a large discharging capacity, not only when a freshet might cause a rise in the lake, but also with the lake at its normal level of 85 ft. above the sea, so that water might be drawn off in anticipation of freshets.

About midway in the length of Gatun Dam there was a rocky hill outcropping, which provided an excellent site for the regulating works, affording a suitable foundation for the heavy masonry structure and being near enough to the locks to be easily defended in time of war. The extent of this available foundation determined in part the length of the spillway dam and, consequently, the elevation of the crest, which was placed at 69 ft. above sea level, or 16 ft. below normal lake level.

No data on the value of the coefficient of discharge for a dam with from 16 to 18 ft. depth of water on its crest were avail-

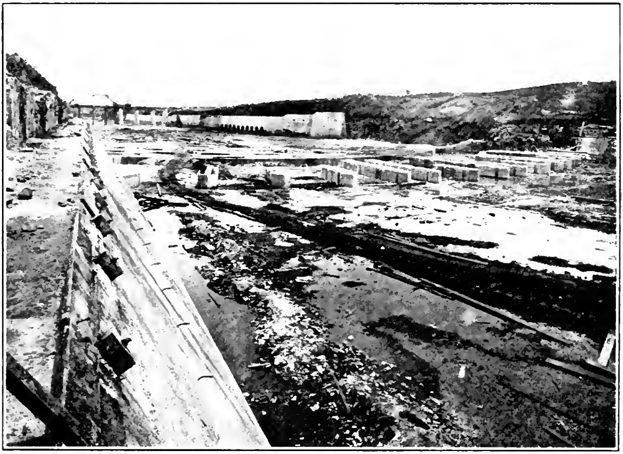


FIG. 1. GATUN SPILLWAY. SITE OF DAM.

able, the greatest head for which there was definite information being 7 ft., at La Grange dam in California. The effects of the unusual depth, the proposed shape of the crest and of the piers necessary to hold the gates, were therefore studied with considerable care and it was estimated that in the formula $q = C(L - 0.2h)h^{1.5}$ the coefficient would not be less than 3.0, and that it would probably be about 3.5.

With Gatun Lake at its ordinary elevation of 85 ft. above sea level, giving a depth of 16 ft. on the crest, and with $C = 3.47$,

$q$ becomes 10 000 sec.-ft. from each 45-ft. gate opening. If the lake is at its maximum elevation, giving a depth of 18 ft., $q$ will be 10 000 sec.-ft., with $C = 3.0$. It seemed reasonable, therefore, to expect that such a discharge would occur without causing the lake to rise above the 87-ft. level, and the spillway dam was accordingly designed to have 14 of the 45-ft. openings, insuring the desired total capacity of 140 000 sec.-ft. The total clear

FIG. 2. GATUN SPILLWAY. LAKE DISCHARGING OVER SITE OF DAM AND THROUGH CHANNEL.

crest length is 630 ft. and the total distance between abutments is 760 ft.

It is interesting to note that recent measurements of the discharge from a single opening showed that about 11 000 sec.-ft. were passing when the depth on the crest was 17 ft. For this discharge and head the value of $C$ is 3.94, and if this is the true coefficient the total capacity of Gatun Spillway at high water is 174 000 sec.-ft., which is larger than is likely ever to be required.

In his paper on "Engineering Lessons from the Ohio Floods,"* published in our JOURNAL in 1914, Mr. John W. Alvord showed a curve giving values of $C$ for heads up to 11.5 ft. Exterpolating on that curve would give a value of about 3.6 for a head of 16 ft.

Although the crest of the dam was made of a form which, while providing seats for the Stoney gates and for the caisson needed to permit repairs to be made, would facilitate the flow

FIG. 3. GATUN SPILLWAY. MIDDLE SECTION STOPPED AT ELEV. 50. OPENINGS THROUGH DAM FOR CONTROL OF LAKE DURING CONSTRUCTION.

of the water, the design of the downstream face was controlled by the principle that the nappe should adhere to the masonry to prevent air from entering under it to cause chattering and the consequent lifting action, which, with such an enormous quantity of water, might be dangerous to the structure.

In determining the profile of the dam, it was not considered necessary to use the velocity of flow through the orifice which

* JOURNAL Boston Society of Civil Engineers, Vol. I, p. 85.

exists under a gate while it is being opened, as the amount of water would then be too small to do any harm. At the same time it was not considered safe to use the lower velocity of flow over the weir which exists when the gate is fully opened, as a large amount of water would pass during the last stages of opening and the first stages of closing a gate and while the gate was still immersed on its lower edge. It was assumed that the horizontal velocity, due to the gate being open 6 ft., was a reasonable one to use, and the upper part of the downstream face of the dam was made a parabola, convex upward, of the form $h^2 = 42v$, this being slightly flatter than the natural curve of the overflowing stream. To turn the water back to the horizontal direction at the toe of the dam without serious disturbance, the lower part of the face was designed to be a circular curve of long radius, concave upward.

The general plan and the cross-section of the spillway dam which was adopted and built are shown in Plates I and II. The crest is divided into openings or bays by piers which extend above the crest high enough to permit the Stoney gates to be raised clear of the water and to allow the safe passage of drift. It is not expected, however, that any considerable amount of drift will reach the spillway, for in a lake so great and of such irregular contour as that formed by the Gatun Dam, the currents towards the outlet will ordinarily be inappreciable except in the immediate vicinity of the spillway. The course of floating substances will therefore be determined by the wind rather than by the current, and they will be stranded on the shores.

The floor of the spillway channel below the dam is 10 ft. above sea level, so that there is no pool to serve as a cushion for the overflowing water, which, having fallen 75 ft., has a velocity of about 60 ft. a second. Such a velocity would be dangerous to the floor of the channel, and the depth of the stream could not be determined, since, under such conditions, the great initial velocity and correspondingly small cross-section may be retained, or, without apparent reason, the depth and area of section may increase and a less velocity be assumed, or stationary waves may be formed, the velocity of the stream being different at different points in the channel.* This uncertainty made it seem essential that some positive method should be devised for reducing the velocity of the flow at the toe of the dam so as to obtain a condition of uniform flow at a reasonable velocity in the discharge channel. It was not deemed safe to depend upon the convergence of streams from the curved crest towards the common center to destroy the energy created by the fall, and a system of baffles was consequently introduced in the

FIG. 4. GATUN SPILLWAY DAM. BAFFLE PIERS IN FOREGROUND. ENTRANCE TO MACHINERY TUNNEL IN DISTANCE.

floor just below the dam. A somewhat similar system of baffles had been used below the overflow pool at the Wachusett Dam, and a solid wall had been used for the same purpose below a dam in Utah.†

The water flowing over the face of the dam has a depth of about 6 ft. when it reaches the baffles, which are 9 ft. high.

* Proc. Am. Soc. C. E., September and November, 1915.

†Trans. Am. Soc. C. E., Vol. LXII, p. 49.

Striking them, it turns vertically upward and much of its energy is used in internal work and converted into heat. The stream immediately below the baffle piers has a depth of approximately 20 ft. and a velocity of about 20 ft. per second.

The spillway channel is 285 ft. wide and 960 ft. long, its length being such that the water is discharged beyond the limits of the earth dam at a point where erosion will do no harm. The concrete floor varies in thickness from 4 ft. at the upper end to 1 ft. at the lower end, except that in the apron immediately below the toe of the ogee and around the baffle piers, where the velocity of the overfalling water is reduced and great disturbances are caused, it is 12 ft. thick.

It seemed desirable to make some tests with a model to determine by actual experiment whether the proposed arrangement of baffles might be expected to accomplish the desired result. A model was made, therefore, on the scale of $\frac{3}{8}$ in. to a foot, the curved ogee section being made of concrete carefully placed between wooden battens sawed to the proper shape. The crest piers were of wood, grooved for wooden gates so that the discharge could be regulated at will. The baffles were wooden blocks, fastened to the floor with screws so that they might be moved about. The water supply was obtained from the drainage from the hydraulic fill in the interior of Gatun Dam, and a by-pass with gates made it possible to regulate the flow so as to get any desired depth on the crest. Experiments were made, first, with all baffles in place; second, with only the row of larger upstream baffles in place; and, third, without baffles. The tests without the baffles indicated clearly that it would not be desirable to omit them, as the converging streams of water formed a very large stationary wave at the upper end of the channel. With one row of baffles in place there seemed to be more disturbance than with two rows, while the results obtained with two rows of baffles in place indicated that they would give the desired results.*

The baffle piers as built are of concrete, like the rest of the structure, but they are heavily reinforced with steel rails and their upstream faces are armored with very thick, ribbed, iron

* *Engineering Record*, June 4, 1910.

castings, so that such drift as may strike them will not easily destroy them. If they are destroyed or badly damaged, they can be replaced or repaired in the dry season when no water will be discharged from the lake. (Plate III.)

Each crest gate weighs about $42\frac{1}{2}$ tons. It is essentially a steel frame, consisting of two end posts, four horizontal main girders, and three vertical cross girders with intercostals and braces. The frame is covered on the lake side with water-tight steel plates, butt-jointed with calked cover plates. The water pressure on the gate is transmitted from the end girders through equalizing rocker bearings and roller trains to cast-steel bearing plates set in the concrete of the piers. Cast-iron side plates are also set in the concrete piers to serve as bearings for bronze water seals at each end of the gate. The bottom contact of the gate is made on a babbitt seat.

These gates are operated electrically by machines installed in a tunnel extending throughout the length of the dam and beyond it, through the earth, to the vicinity of the power house on the east side of the discharge channel, where the control board is located. The gates are lifted by means of chains, attached to the ends, passing over sheaves on the tops of the piers; thence down through pipes in the masonry to the tunnel, where they are attached to vertical stems, threaded and engaged in the operating nuts, which are driven by worms at the ends of the main shaft, back geared to the motor. Counterweights, traveling in pits under the tunnel floor, are attached to the lower ends of the stems so that comparatively little power is required for operation.

The openings between the crest piers, above the gates, are spanned by steel foot-bridges which can be removed if necessary for the installation of new gates. Auxiliary hand operation is provided, so that means are available for opening the gates even though the electrical machinery should break down.

The spillway dam was constructed in the following manner: A cut was made through the hill which had been selected as the site of the spillway, and a concrete floor and side walls were put in except at the site of the spillway dam, where low piers were built in the channel to key the dam to the rock and to serve for supports for such stop-planks or cofferdams as were necessary to shut off the water and permit the placing of concrete in the dam. (Fig. 1.) When the construction of the Gatun Dam had proceeded far enough to cause the closure of the natural outlets of the rivers, the slowly forming lake found a new one ready in this artificial channel. (Fig. 2.) It discharged through this channel during one rainy season. During the succeeding dry season the lake surface fell so low that the depth of water at

Fig. 5. Gatun Spillway, with 7 of 14 Gates Open, Showing Effect of Baffle Piers.

the side of the dam was only about 1.5 ft. The stop-planks were then easily put in between the piers, and the flow entirely stopped. The construction of the dam then proceeded, the piers being carried up ahead of the rest of the work. Then the ends of the dam were carried up to full height, while the middle section was stopped at elevation 50, so that under no circumstances might the lake rise so high as to interfere with excavation in Culebra Cut. (Fig. 3.) Although the lake did overflow the temporary crest of the dam at elevation 50 in one great freshet which occurred during the following wet season, it was controlled most of the time by three low-level culverts, left through the body of the dam and provided with some of the sluice gates afterwards installed in the lock-filling culverts. (Fig. 3.) As soon as the work of excavation of the Canal permitted it, the middle section of the dam was completed to full height, the crest piers carried up, the gates and machinery in-

FIG. 6. GATUN SPILLWAY COMPLETED AND DISCHARGING ABOUT 75 000 SEC.-FT.

stalled, and the foot-bridge spans set in place. The low-level culverts were then closed at their upstream ends by heavy wooden gates, the steel gates were removed and the culverts filled with concrete. (Fig. 4.) The completed dam, with water flowing through seven of the fourteen gate openings, is shown in Figs. 5 and 6.

The concrete plant for Gatun Spillway, consisting of a dock, material platform, cement shed and mixer building, was located on the old French canal, about 5 000 ft. away from the dam. The materials were brought to the concrete plant by water and the prepared concrete was hauled to the work by steam locomotives on a narrow gage railway. Each train consisted of two cars carrying two batches of two cubic yards each. They were run at about 25 miles per hour, and no difficulty was found in removing concrete from the plant as fast as it was mixed.

About 225 000 cu. yds. of concrete were used in Gatun Spillway, nearly all of it being a 1:3:6 mixture. Although there was a large amount of mass concrete, the difficult work in the piers raised the average cost to $8.00 per cu. yd. The excavation amounted to 1 550 000 cu. yds., and it cost an average of about $0.71 per cu. yd. Including operating machinery, gates, caisson and miscellaneous details, the total cost of the work was about $3 450 000.

## Miraflores Spillway.

The Miraflores Spillway, which serves to control the small Miraflores Lake, is located east of the locks and connects them with the rock ledges of the hills on that side. Although this spillway has some features like the corresponding ones at Gatun, the problem of design was a very different one owing to the peculiar conditions above the lake.

That such an accident as happened at the locks in the St. Mary's River* about five years ago may happen to the lock gates at Pedro Miguel is not impossible, and proper control of Miraflores Lake involves, therefore, not only passing the insignificant flow of the tributary streams, but the disposal of the large amount of water which would come down from the higher level of Gatun Lake through Culebra Cut should an accident permit an unobstructed flow to take place through one of the twin locks at Pedro Miguel.

Careful studies were made of the quantity which might be expected to flow into Miraflores Lake should this contingency arise, and the spillway which was designed with a capacity at

* *Engineering News*, June 17, 1909.

maximum permissible lake level of about 92 000 sec.-ft. is believed to be ample. The quantity which will flow into the lake is not susceptible to exact determination, as the judgment of the engineer determines the constants used in the formulas, and results ranging from 75 000 sec.-ft. to 116 000 sec.-ft. were obtained by different computers. It is probable that the true value lies between 90 000 and 100 000 sec.-ft., but, in case the inflow is found to be greater than has been predicted and greater

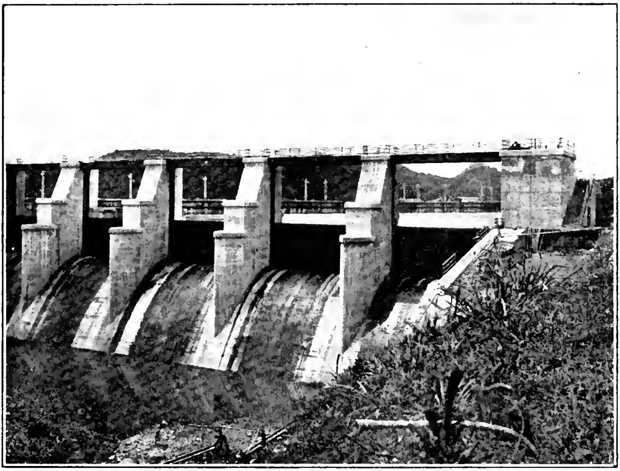


FIG. 7. MIRAFLORES SPILLWAY. COMPLETED DAM. POOL IN FRONT OF DAM IS ABOUT 25 FT. DEEP.

than the spillway dam can discharge, the filling culverts of the Miraflores locks can be opened to provide an additional capacity of some 25 000 sec.-ft.

The spillway dam is a straight concrete dam of ogee section with its crest 16 ft. below the ordinary level of Miraflores Lake. (Plate IV.) The crest of the dam is divided into eight bays, similar to those on the spillway dam at Gatun, the piers being so designed that the caissons for closing off gate openings may be used interchangeably at both spillways. (Plate V.)

Although the tide in the Bay of Panama has a range of about 20 ft., a sill, or part tide dam, in the Rio Grande at Corozal, a few miles below Miraflores, prevents the water above it from falling with the tide, so that the surface of the pool below the dam varies only between elevations 6 and 10, the depth of water at the toe of the dam varying from 21 to 25 ft. (Fig. 7.) With a pool of such depth and of considerable area below the dam it did not seem necessary to use baffle piers, such as were adopted in the design of the Gatun Spillway, to check the velocity at the toe. Besides, while it would not be wise to omit provision for it, the accident that will make it necessary to utilize the full capacity of the Miraflores Spillway is a remote probability and may reasonably be anticipated only at extremely long intervals of time, and the amount of erosion at the toe of the dam, due to the discharge over it of such amounts as are necessary for ordinary lake regulation, will undoubtedly be very small.

The area of the watershed tributary to the lake is 66 sq. miles. From this it was estimated that a maximum run-off of 7 650 sec.-ft. might occur. Ordinary lake regulation was estimated to require a discharging capacity of about 3 000 sec.-ft., and, although it was at one time proposed to install subsidiary culverts through the dam so that the heavy crest gates might not have to be opened for this purpose, it was finally decided to omit them. It seemed better that the crest gates should be operated frequently, so that the men in charge might have experience in working and caring for the machinery and because every time a gate is raised an opportunity is afforded for examination of its condition and even for painting.

The machines for operating the gates are placed in a tunnel, running through the body of the dam from end to end, just as in the Gatun Spillway. As the flood that would be thrown into Miraflores Lake by the breaking down of a lock at Pedro Miguel would raise the lake level at the rate of a tenth of a foot a minute, and as the top of the earth esplanade around the locks is only 4 ft. above ordinary lake level, it is evident that after the accident happens the spillway gates must be opened promptly. The ordinary manual control of the electric motors which lift them is therefore supplemented by an automotic self-starter, actuated by a float switch in a well in one of the abutments, connected with the lake so that when the water rises beyond a certain predetermined level the gates are opened.

About 75 000 cu. yds. of concrete, at an average cost of $6.85 per cu. yd., were required in the construction of the Miraflores Spillway. Excavation amounted to some 166 000 cu. yds., and cost at the average rate of $0.69 per cu. yd. The total cost of the work, including gates, operating machines, caisson and miscellaneous details, was about $985 000.

## Floating Caisson.

Although it is expected that the crest gates of the spillways can ordinarily be painted when raised out of the water, it may happen that the work to be done is more extensive than can be accomplished in the short time that a gate can be left open, or it may be necessary to make repairs in the dry season when it is not desirable that any water be needlessly wasted. A floating steel caisson, similar in many respects to a dry-dock gate, has therefore been provided, so that work may be done on a crest gate behind its shelter. This caisson, which is merely a rectangular steel box provided with timber sills and keels so that it may fit tightly against the masonry, can be floated into its place behind the crest gate to be repaired and water admitted into it in sufficient amount to cause it to sink to its seat. Opening the Stoney gate a few inches will then permit the escape of the small amount of water between the gate and the caisson, and will cause an unbalanced pressure on the upstream side of the caisson which will force it tightly against the vertical seats and permit very little leakage.

Upon the completion of the work on the gate, water will be readmitted to the space between the gate and the caisson by means of a pipe passing completely through the caisson, and the latter will be pumped out and towed away, there being sufficient permanent ballast in it to make it float upright in the water.

Study was made of two types of construction, reinforced concrete and steel. It was necessary to use longitudinal steel girders in either case, to span the long opening, and the first type, although called reinforced concrete, would have been so only in the use of slabs of that material as sheathing for those parts that would be inaccessible without docking. A preliminary design was worked out, but the all-steel caisson seemed preferable and was designed in detail. Sections of the latter and a side elevation with the sheathing removed to show the interior equipment are shown in Plate VI.

There will be no difficulty in painting the caisson, as it can be dry-docked in one of the locks of the canal when the lock gates are to be inspected or painted. It will be kept at a prepared anchorage ground, where the depth of water is such that, should sufficient leakage occur to cause it to sink, it will not go deep enough to prevent easy recovery.

## Retaining Walls.

Rather high retaining walls were required at the sides of the approach channels at Gatun Spillway and at the sides of the discharge channel of Miraflores Spillway. Those at Gatun were 45 ft. high for a considerable part of their length, and as they had to withstand the pressure of the fluid hydraulic fill of the earth dam before Gatun Lake could be filled to help sustain them with water pressure on the front, the conditions were rather severe. The filling was assumed to exert a horizontal pressure equivalent to that of a liquid weighing 75 lbs. per cubic foot, but, at the same time, exerting an actual vertical weight of 125 lbs. per cubic foot in the horizontal steps at the back of the wall. These walls rest on a firm argillaceous sandstone, and under the given assumptions the line of resistance falls a little outside of the middle third, but the maximum pressure at the toe is only 110 lbs. per square inch. With the lake filled, the line of resistance is inside the middle third, and the maximum toe pressure is 62 lbs. per square inch. The base width is $27\frac{1}{2}$ ft., giving a ratio of base to height of .61.

PLATE I.
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
APRIL, 1916
SHERMAN ON
SPILLWAYS OF PANAMA CANAL.

GATUN SPILLWAY.
GENERAL PLAN OF DAM.

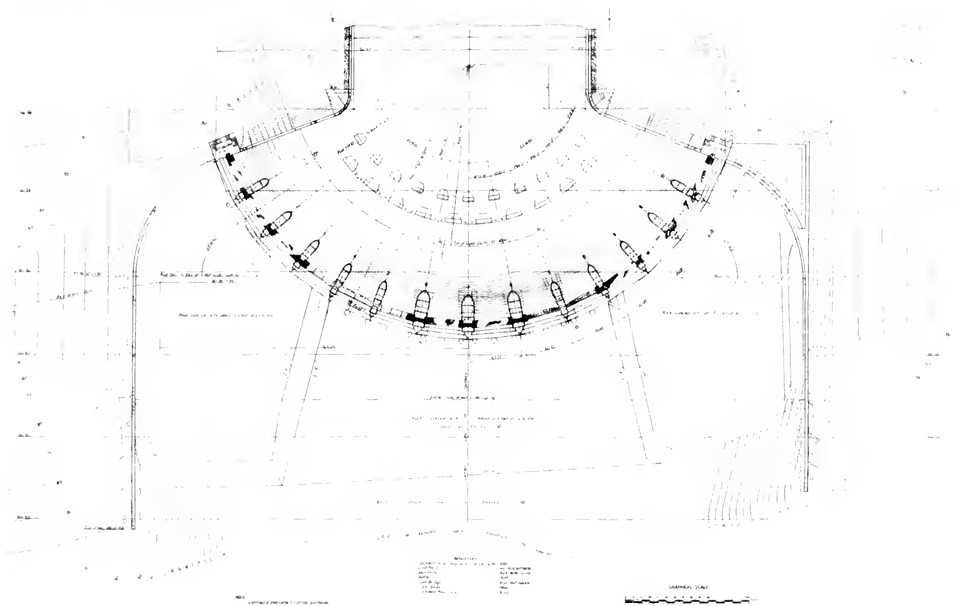
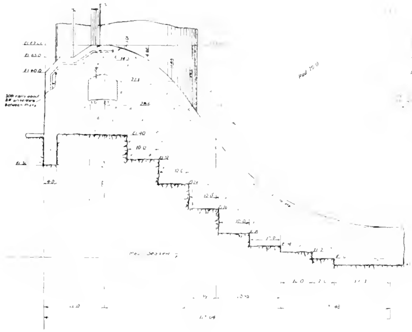
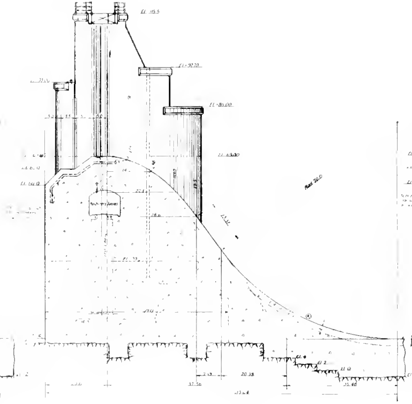


PLATE II
JOURNAL BOSTON SOCIETY OF
CIVIL ENGINEERS
APRIL, 1916
SHERMAN ON
SPILLWAYS OF PANAMA CANAL

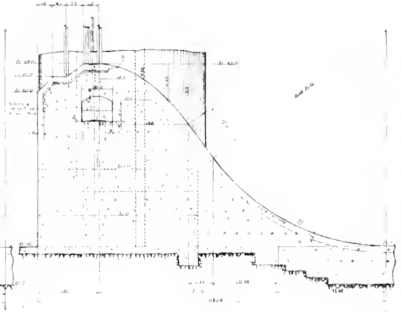
## GATUN SPILLWAY
## SECTIONS OF DAM.



SECTION C-C



SECTION B-B
Showing relation of Pier B to Spillway Dam



SECTION A-A
Showing relation of Pier A to Spillway Dam

PLATE III.
JOURNAL BOSTON SOCIETY OF
CIVIL ENGINEERS.
APRIL, 1916.
SHERMAN ON
SPILLWAYS OF PANAMA CANAL.

## GATUN SPILLWAY.

## DETAILS OF BAFFLE PIERS AND METAL FACES

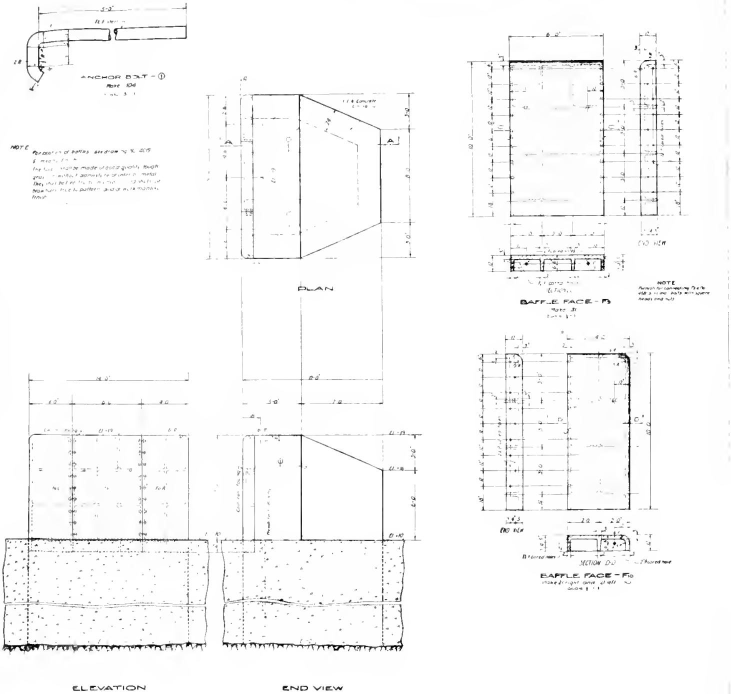


PLATE IV.
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
APRIL, 1916.
SHERMAN ON SPILLWAYS OF PANAMA CANAL.

**MIRAFLORES SPILLWAY.**
**GENERAL PLAN.**

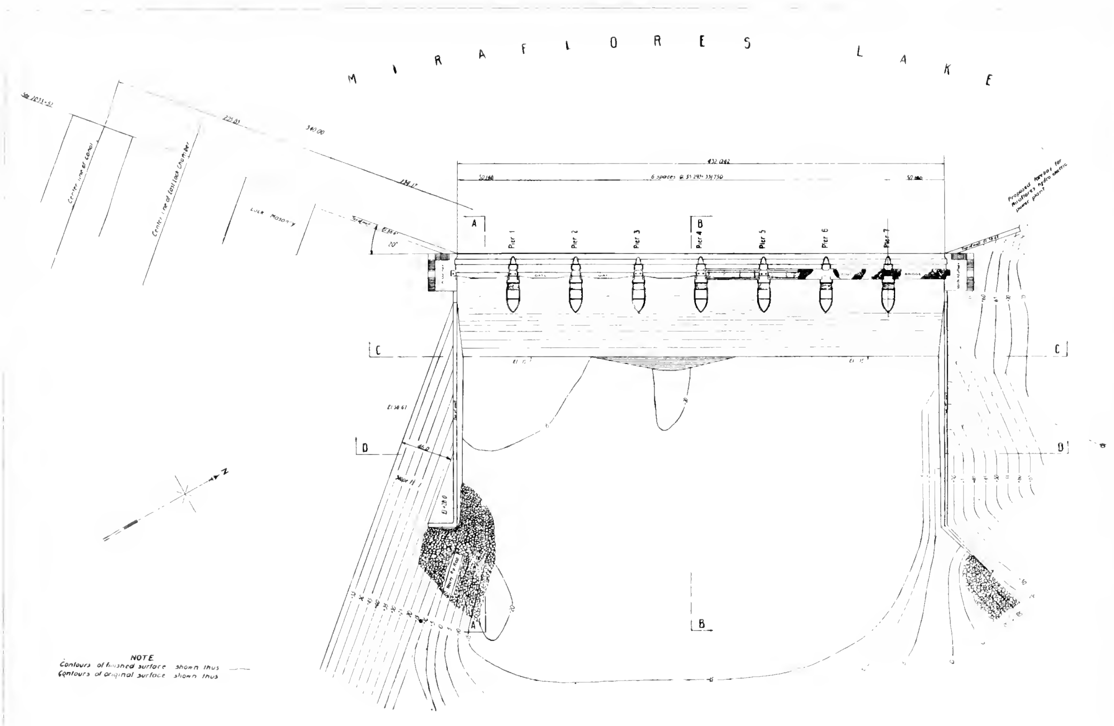
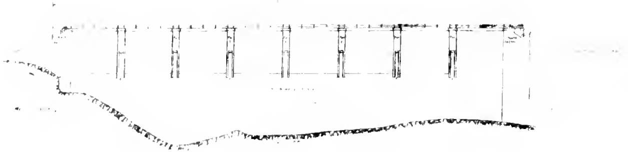
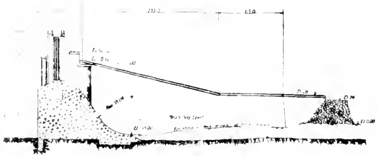


PLATE V
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
APRIL, 1916.
SHERMAN ON SPILLWAYS OF PANAMA CANAL.

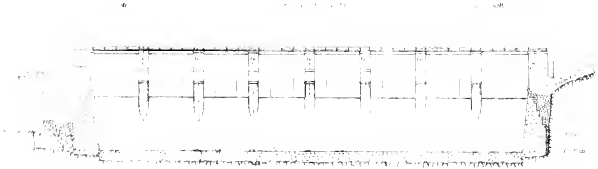
## MIRAFLORES SPILLWAY. ELEVATIONS AND SECTIONS.



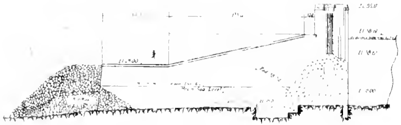
UP STREAM ELEVATION



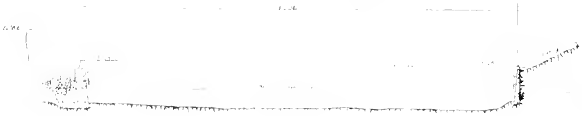
SECTION B-B



SECTION C-C
and down stream elevation of dam



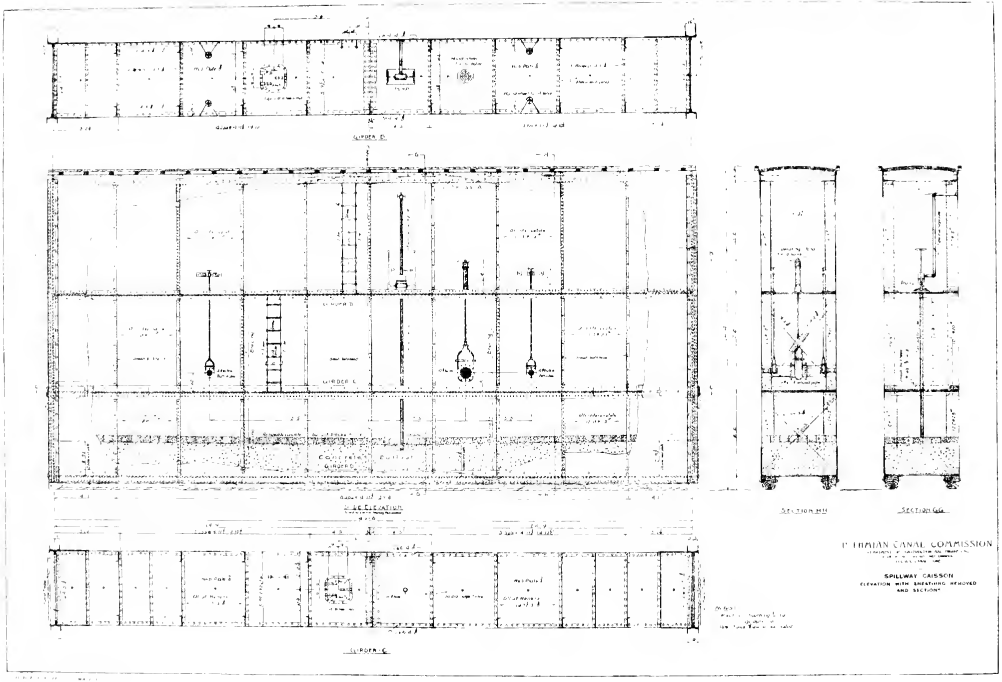
SECTION A-A



SECTION D-D

PLATE VI.
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
APRIL, 1916.
SHERMAN ON
SPILLWAYS OF PANAMA CANAL

## CAISSON.



## DISCUSSION.

Mr. Louis K. Rourke.* — In connection with the very able paper to which we have just listened I have not much to say except that the successful working of the Panama spillways since they have been put in operation is a tribute to the skill and training of our fellow-member, Mr. Sherman, who designed them.

The most spectacular thing in connection with the construction of this work was the damming of the river at Gatun and turning the water through the completed spillway channel. When the Americans took charge of the work at Panama, the Chagres River was flowing through three channels at the site of the Gatun dam. The most easterly one was the natural bed of the Chagres, the second channel was the sea-level canal which the French had dredged for a distance of fifteen miles inland, and the third channel was the west diversion, which was located to the west of Spillway Hill. As the construction of the Gatun dam progressed, the two easterly channels were completely filled during 1908, and the entire flow of the Chagres was sent through the west diversion. The grade of the trestle which spanned this diversion and carried the dump tracks was about 30 ft. above sea level.

In April, 1910, the spillway channel being ready, orders were issued to block the west diversion and turn the Chagres through the spillway. The filling began on April 22, and was entirely completed and the water running through the spillway on April 25. On April 23, 760 carloads of spoil were dumped in the west diversion. These cars would average about 15 cu. yds. per car. The problem was to have plenty of material on hand and to keep it coming until the river was blocked. This was successfully done.

* Of Rourke & Sherman, Consulting Engineers, Boston.

Vol. III APRIL, 1916 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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# THE LATEST METHOD OF SEWAGE TREATMENT.

By Edward Bartow, Ph.D.*

(Read before the Sanitary Section, January 10, 1916.)

Sewage treatment by aëration in the presence of sludge is the latest development in sewage disposal, although air has always played an important rôle in sewage disposal. Its earliest application was in the exposure of sewage on the ground or in shallow pools, and the disposal of sewage by irrigation is, therefore, an aëration process. No more sewage can be disposed of on land than can be thoroughly oxidized, and the disposal of sewage by dilution in streams depends also on the amount of air present, the amount which can be purified by a stream being limited by the amount of dissolved oxygen present.

Intermittent sand filtration, with sewage added intermittently to sand beds, is an aëration process for, between the periods of flooding with sewage, air is allowed to enter the pores of the sand. The action of contact beds is of a similar nature; coarser material is used, and between the periods of flooding air enters the interstices and is the purifying agent. Sprinkling filters, the most practical process up to the time of the suggestion of activated sludge, depend upon aëration obtained by spreading the sewage in a finely divided state into the air.

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the Journal.

* Director, State Water Survey, University of Illinois.

Preliminary to these aëration processes preparatory treatment, consisting in using screens, grit chambers, settling tanks, digestion tanks or chemical precipitation, is necessary. The kind of preparatory treatment varies according to conditions. For example, three European cities use different degrees of preparatory treatment prior to disposal by dilution. Munich uses no screening whatever, the water in the Yser being of sufficient quantity and sufficiently aërated to dispose of the sewage. Hamburg can dispose of its sewage in the lower Elbe, using only coarse screening; but Dresden, on the upper Elbe, must pass its sewage through fine screens before emptying it into the river.

Grit chambers and settling tanks remove suspended matter, and the amount of purification is comparable with the amount of purification by screening. Digestion tanks accomplish the partial destruction of the suspended solids and of the soluble organic matter by the action of anaërobic bacteria. The addition of certain chemicals assists sedimentation and retards digestion, giving an increased amount of sludge, but a much improved effluent. Neither screening, sedimentation, digestion nor chemical precipitation produces complete purification, and aëration processes must complete it.

The latest process, the aëration of sewage in the presence of sludge, has had a gradual development, numerous experiments of blowing air into sewage having been made both in America and in Europe. Until recently none of them were at all promising and the conclusion was that such means of purification were not practical. In this country, the first promising method was that used by Black and Phelps* in New York, in which air was blown through the sewage as it passed over a series of inclined wooden gratings. This sewage was in contact with the air for varying periods up to twenty-four hours and the results were promising enough to cause Black and Phelps to recommend the construction of a larger plant for Greater New York. That plant has not been constructed and the experimental tank has been adapted to experiments with activated sludge.

The next experiments are those reported by Clark, Gage

* Report Concerning Location of Sewer Outlets and the Discharge of Sewage into New York Harbor, (1911) 64–78.

and Adams* at the Massachusetts State Board of Health Experiment Station in Lawrence. Air blown through sewage was found to reduce the organic constituents, and the seeding of the sewage with green growths accelarated the action. Their best results were obtained when the tank contained slabs of slate covered with a brown growth of sewage matters. This treatment produced an effluent which could be filtered at several times the normal rate but it simply prepared the sewage for treatment on sand beds, and was not considered a final process.

Gilbert J. Fowler, of the University of Manchester, England, was in this country in November, 1912, in connection with the disposal of the sewage of Greater New York, and visited the Massachusetts Experiment Station. Fowler and Mumford carried on experiments with a specific bacillus which they named M-7 and which was collected from the waste water from a colliery. This bacillus, with aëration, has the power of separating iron as ferric hydroxide from iron-bearing sewages, carrying down with it the suspended matter and furnishing a non-putrescible effluent. Fowler suggested to Ardern and Lockett, who were in charge of the Manchester Sewage Disposal Works, that they try experiments in aërating sewage on lines somewhat similar to what he saw in Massachusetts. As a result, the activated sludge process is being developed.

The first description of it was given by Ardern and Lockett,† April 3, 1914, at a meeting of the Manchester Section of the Society of Chemical Industry. In their first experiments, Ardern and Lockett used bottles having a capacity of five pints, and drew the air through the sewage by means of an ordinary filter pump. Air was drawn through the sewage until it was completely nitrified, requiring about five weeks. The supernatant liquid was then drawn off, additional sewage added and the treatment repeated a number of times with the retention each time of the deposited solids. As the amount of deposited matter increased, the time required for each succeeding oxidation gradually diminished. Finally, a well-oxidized effluent,

* Annual Report, Mass. State Board of Health, (1913) 45, 288–304.

† Jour. Soc. Chem. Ind., *33*, 523–539.

equal to that from efficient bacterial filters, was obtained in from six to nine hours.

In their second series of experiments, reported to the Manchester Section of the Society of Chemical Industry,* November 6, 1914, they used barrels of 50 gal. capacity and added the air through porous tile. They have tried treatment with a continuous flow of sewage without conclusive results. In later experiments they used tanks of 20 000 gal. capacity. Their results were very satisfactory and led to additional work in England, especially at Salford, where Duckworth† and Melling‡ adapted scrubbing filters to the use of the activated sludge process with great success. In August, 1914, I had the privilege of meeting Professor Fowler, and of seeing the work which had been done under his direction. On returning to this country, consulting with Fowler, experiments§ were begun with F. W. Mohlman, at the University of Illinois, on November 2, 1914, using bottles of 3 gal. capacity. On January 4, 1915, a tank 9 in. square and 4.5 ft. deep, in the bottom of which was placed a porous plate made of " Filtros," was put in operation. These plates are made of a very pure and carefully graded quartz, fused together with powdered glass.

The results of our first experiments were similar to those of Ardern and Lockett. Sewage placed in the bottles or in the little tank was submitted to a current of air for a sufficient period to oxidize it completely. The oxidation is best measured by the content of ammonia, nitrate and nitrite nitrogen. Oxidation has been carried to completion five different times with practically the same results. The time required for oxidation differed, but the courses of the reaction were similar. As an example, in one of these experiments, at the beginning, 35 parts per million of ammonia nitrogen were present. (Fig. 1.) The ammonia nitrogen remained practically constant for about four days, then quite rapidly decreased so that at the end of about

* Jour. Soc. Chem. Ind., *33*, 1122–1124 (1914).

† Surveyor, *46*, 681, 682 (1914).

‡ Jour. Soc. Chem. Ind., *33*, 1124–1130.

§ Jour. Ind. Eng. Chem., *7*, 318 (1915). *Eng. News*, *73*, 647, 648 (1915). *Eng. Record*, *71*, 421, 422 (1915). *Eng. Contrg.*, *43*, 310, 311 (1915).

seven days it was gone. There were no nitrates nor nitrites present in the raw sewage. The nitrites increased as the ammonia decreased. Then for a few days the nitrites remained constant and then decreased, the nitrates which were zero at the start increasing as the nitrites decreased. At the end of fifteen days, nitrification was complete, the nitrite nitrogen had practically disappeared and the nitrate nitrogen had increased to about 25 parts per million. When the oxidation was complete the

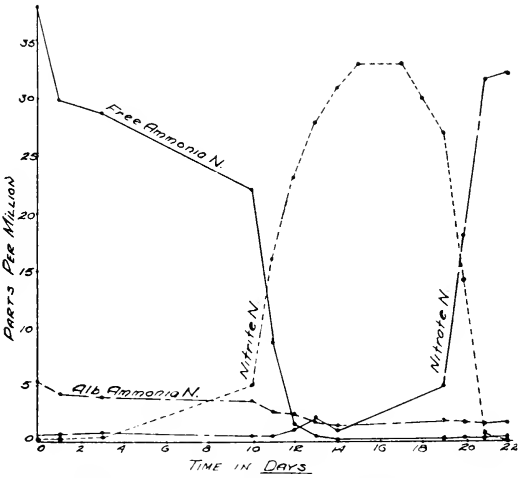


FIG. 1. NITRIFICATION OF SEWAGE. NO ACTIVATED SLUDGE PRESENT.

supernatant liquid was replaced by fresh sewage, the sludge being left. This process was repeated and with each change less time was required for oxidation, as, for example, fifteen days for the first, four days for the second, and two days for the third; and so on, until with the thirty-first treatment oxidation was complete in five hours.

With accumulation of sludge as the process is repeated, the reaction follows a different course; for example (Fig. 2), using a sewage with 27 parts per million of ammonia nitrogen, the ammonia decreased and is practically eliminated in five hours. The nitrite nitrogen never increased to any extent, the nitrate nitrogen begins to increase almost at the start, increasing as the ammonia nitrogen decreases, and reaches its maximum when the ammonia nitrogen has disappeared. It is not necessary to obtain complete nitrification to obtain a clear or stable effluent. More

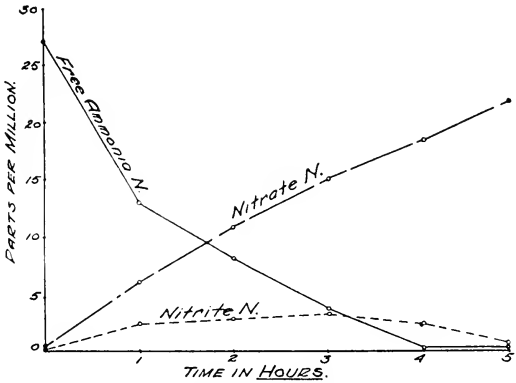


FIG. 2. NITRIFICATION OF SEWAGE. ACTIVATED SLUDGE PRESENT.

information must be obtained before the amount of nitrification required can be known.

The process is undoubtedly bacteriological. The sludge is very rich in bacteria but the number in the effluent is comparatively small. In our laboratory, Mr. Robbins Russell investigated the bacteriological properties of the sludge. Several species of bacteria were isolated from the sludge, including two kinds of nitrifiers and about fifteen other varieties. Experimenting with sterilized sewage, it was found that the nitrifiers alone would not purify the sewage, but that mixtures of the nitrifiers with the other bacteria would completely purify it.

In an article which was presented before the American Chemical Society* mention was made of some worms which developed in the process and which were identified by Prof. Frank Smith of the Zoölogical Department of the Univ. of Illinois as Aeolosoma Hemprichi. It seemed possible that these worms might play an important rôle in the purification process. Having isolated about two hundred of these worms as completely as possible from the bacteria and sewage, Mr. Russell added them to sterilized ammonia broth and aërated it, obtaining practically no nitrification. The worms are, therefore, not essential, and the bacteria which were isolated from the sludge did nitrify sterilized sewage.

The fresh sludge is odorless, will putrefy if left with a large amount of water, but after filter pressing it is stable. The dried sludge has an odor similar to that of fertilizers.

As in other sewage disposal processes, the ultimate disposal of the sludge is of great importance. Near the seaboard it is possible to carry it out to sea, but, in the interior, the problem of sludge disposal is often very serious.

In the experimental plant at the University of Illinois in Urbana, we have tried to study all phases of the process,† and have paid especial attention to the sludge.

The amounts of sludge formed and its chemical composition evidently vary with the concentration of the sewage and with temperature conditions. The sewage treated in the experimental plant during rainy weather contains large amounts of diluting water, which reduces the amount of sludge per unit of water and this water carries considerable dirt from the streets, which reduces the nitrogen content of the sludge obtained. Also, during warm weather, bacteriological action is more rapid, and apparently the amount of sludge is considerably reduced.

The sludge obtained in the process is flocculent, resembling a freshly formed precipitate of ferrous-ferric hydroxide. It separates easily from the clarified water, and after settling one hour contains about 98 per cent. of water. On further standing, about one half of this water can be removed. The remaining

* Jour. Ind. Eng. Chem., 7, 318 (1915).

† Jour. Ind. Eng. Chem., 7, 318–320.

material can be dried by filter pressing or by drying on beds of sand and evaporating over steam baths.

The disposal of the sludge can be most easily accomplished if it has manurial value. That activated sludge has manurial value is shown by its chemical composition, by its reaction with various soils and by its effect on the growth of plants. Specimens of sludge obtained at the experimental plant have varied in nitrogen content from 3.5 to 6.4 per cent., the lower values being obtained during periods of high water. Street wash was getting into the sanitary sewers, and, since no grit chamber was provided, the nitrogenous value of the sludge was greatly lowered. The tests of the fertilizer value have been made on the richer specimens which were first obtained.

Through the courtesy of Mr. Paul Rudnick, chief chemist, Armour & Company, Chicago, the availability, according to alkaline permanganate method as used by the New England states, was shown to be 44.7 per cent., and the sludge would be classed as an inferior ammoniate, but the availability according to the neutral permanganate method which has been adopted by the southeastern states was shown to be 89.0 per cent. and would, therefore, be classed as satisfactory.

Tests have been made by Prof. C. B. Lipman, according to a method described by Lipman and Burgess,* in which a fertilizer and a soil are incubated for a month. The amount of nitrogen changed into nitrate is then determined. This amount is an index of the availability of the nitrogen with respect to the soil used. The results obtained were reported by Professor Lipman as follows:

"The activated sludge used contained 6.2 per cent. total nitrogen and no nitrate. The hundred grams of soil in every case contained nitrate as follows:

| | |
|---|---|
| Anaheim soil | 1.0 milligram nitrogen. |
| Davis soil | .3 milligram nitrogen. |
| Oakley soil | .1 milligram nitrogen. |

"The amounts of nitrate produced in one month's incubation from the soil's own nitrogen and from the nitrogen of the sludge mixed with the soil in the ratio of one part of sludge per hundred of soil is as follows:

* Univ. of Calif., Bull. 251 (1915).

Anaheim, without sludge, 6 milligrams nitrate produced.
Anaheim, with sludge, 10 milligrams nitrate produced.
Davis soil, without sludge, 4.2 milligrams nitrate produced.
Davis soil, with sludge, 14 milligrams nitrate produced.
Oakley soil, without sludge, 2.2 milligrams nitrate produced.
Oakley soil, with sludge, 4 milligrams nitrate produced.

"The Davis soil is the best nitrifying soil of the three, especially for high-grade organic material; Anaheim is next and the Oakley by far the poorest. Indeed, the last named does not nitrify, in a period of a month in the incubator, the nitrogen of dried blood.

"These figures indicate that the general tendency is to make available the nitrogen of sludge in type soils at about the same rate that nitrogen is transformed into nitrate in such organic, nitrogenous fertilizers as fish guano. While it seems to hold a medium position, it nevertheless resembles very much more closely in its general characteristics, so far as available nitrogen is concerned, the so-called high-grade organic nitrogenous fertilizers, dried blood and high-grade tankage, etc., rather than the low-grade nitrogenous fertilizers, steamed bone meal, cotton seed meal, garbage tankage, etc."

Although the chemical tests and the nitrification tests with soils indicate that the activated sludge has a high fertilizer value, the final test must be its effect on plant growth. Pot cultures, using wheat, were started in March, 1915,* under the general direction of Prof. C. G. Hopkins and with the assistance of Mr. J. C. Anderson. The contents of the pots in which the wheat was planted were as follows:

| Pot Number. | 1. Grams. | 2. Grams. | 3. Grams. | 4. Grams. |
|---|---|---|---|---|
| (1) White sand | 19 820 | 19 820 | 19 820 | 19 820 |
| (2) Dolomite | 60 | 60 | 60 | 60 |
| (3) Bone meal | 6 | 6 | 6 | 6 |
| (4) Potassium sulphate | 3 | 3 | 3 | 3 |
| (5) Activated sludge | 0 | 0 | 20 | 0 |
| (6) Extracted sludge | 0 | 0 | 0 | 20 |
| (7) Dried blood | 0 | 8.61 | 0 | 0 |

Each pot contained an equivalent of 5 tons per acre of dolomite, one-half ton per acre of bone meal, and 500 lbs. per acre of potassium sulphate.

Pot 1, the check pot, contained only 60 mg. of nitrogen,

* Jour. Ind. Eng. Chem., 7, 318–320.

which were added in the bone meal. This small amount was without significance since the same amount was added to the other pots. Pot 2 contained an equivalent of 120 lbs. of nitrogen per acre, added in the form of dried blood. Pots 3 and 4 contained an equivalent of 120 lbs. of nitrogen in the form of dried activated sludge (one ton of sludge) per acre. Following is an analysis of the sludge used:

| | Per Cent. |
|---|---|
| Total nitrogen | 6.3 |
| Phosphorus ($P_2O_5$) | 2.69 |
| Ether soluble (three hours' extraction) | 4.00 |
| Ether soluble (sixteen hours' extraction) | 11.8 |

Thirty wheat seeds were planted, two seeds in each of fifteen holes, in each pot. In four days the plants were up in each pot, and in ten days were 5 ins. high. At the end of eighteen days, the plants were thinned to fifteen of the best in each pot, in most cases leaving one plant to each hole. In twenty days from date of planting, there was a marked showing in favor of the plants in pots 3 and 4. In twenty-three days, the plants in pots 3 and 4 were growing far ahead of those in 1 and 2.

The plants in pot 2 fertilized with the same amount of nitrogen grew much slower than those in pots 3 and 4. The reason for the poor showing of the plants in pot 2 is not known.

In thirty days, a slight brown mold, which may have been due to the dark, damp weather, appeared on the larger plants, and powdered sulphur was used to fight it. During the fifth and sixth weeks, the plants in the pots fertilized with the sludge, which had grown fully three times as large in height and in amount of foliage as those in the pot fertilized with dried blood, began to yellow. About half of the foliage died, leaving two healthy stalks to each plant. The plants possibly grew so fast, at first, that all the foliage which had started could not develop. The remaining stalks immediately grew stronger and of a deeper blue-green color. After nine weeks, the plants were strong and healthy.

In fourteen weeks the plants in pots 3 and 4 began to head, and in fifteen weeks there were about twenty good heads in each.

The plants in pot 1 were very weak, while those in pot 2 were just beginning to develop heads.

When it was first noticed that the plants fertilized with sludge were growing much better than those fertilized with dried blood, in order to confirm the results a second series of pot cultures was started. In this series the sludge was compared with dried blood, nitrate of soda, ammonium sulphate and gluten meal. This series contained fourteen pots, two check pots, six containing nitrogen equivalent to an application of twenty grams of sludge, and six containing nitrogen equivalent to thirty grams of sludge. The plants in this series grew faster than those in the first because of better weather. They showed exactly the same characteristics that the plants in the other series showed, the plants fertilized with sludge being the best and the results confirming the results obtained in the first series. At the end of five weeks striking differences were noticeable. The pots containing the equivalent of 30 g. of sludge gave no better results than those with an equivalent of 20 g.

When the wheat matured it was carefully harvested and calculations made to determine the yield per acre. The results are shown in a table.

Amounts of Wheat and Straw Obtained in the First Series.

| Pot Number. | 1. | 2. | 3. | 4. |
|---|---|---|---|---|
| Number of heads | 14 | 15 | 22 | 23 |
| Number of seeds | 85 | 189 | 491 | 518 |
| Weight of seeds | 2.38 g. | 5.29 g. | 13.748 g. | 14.504 g. |
| Bushels per acre (calculated) | 6.2 | 13.6 | 35.9 | 37.7 |
| Average length of stalk | 19.4 in. | 23 in. | 35.4 in. | 36.1 in. |
| Weight of straw | 2.25 g. | 8.25 g. | 26.75 g. | 26.21 g. |
| Tons per acre (calculated) | 0.18 | 0.68 | 2.23 | 2.18 |

The control series gave results corresponding to those of the first series.

The surprisingly rapid growth of the wheat fertilized by the sludge must be due for the most part to nitrogen present in a very available form. It may be due in part to the phosphorus (2.69 per cent.) which is present in the sludge, which, at the time of making the pot cultures, we did not consider, since it was present in such a small quantity. The growth may be due in part to the organic matter present in the sludge, since the sand used contains no organic matter. The cause of the molding of the leaves has not yet been determined. It was quite noticeable that the mold appeared chiefly on the leaves of rapid growing plants. In the first series it attacked only plants fertilized with sludge, while in the second series it also attacked the plants fertilized with gluten meal. The rapid growing leaves are naturally more tender than those which grow slowly and consequently are more easily attacked by mold spores. The mold evidently does not come from the sludge, because the extracted sludge surely would be sterile, and plants fertilized with it showed the same mold. Plants fertilized with gluten meal also had the mold.

The sludge causes such a rapid growth of wheat that it should be valuable to truck gardeners, to rush the spring crops. To test its value to the market gardener, three plots, each 2 ft. by 3 ft., were laid out. One was not fertilized, one was fertilized with an equivalent to 126 pounds of nitrogen, one ton of sludge per acre, and the third with an equivalent of extracted sludge. On April 24, 1915, two rows of radishes and lettuce were planted in each of the three plots. The plants in the plot where the extracted sludge was used came up first, a little ahead of those in the plot where the unextracted sludge was used. At the end of two weeks the lettuce and radishes of the treated plots appeared to be twice the size of those in the untreated plot. At the end of four weeks the plants were thinned. The roots of the radishes from the treated plots were already red and quite rounded near the tops, while those from the untreated plots had not yet started to swell and had not become red. The lettuce plants from the treated plots were nearly twice as large as those from the untreated plots.

On June 1, thirty-eight days after planting, the six best plants of lettuce and radishes were taken from each plot. The differences in size were very marked.

COMPARISON OF THE LETTUCE AND RADISHES FROM UNFERTILIZED AND FERTILIZED PLOTS.

| Plot. | Treatment. | Wt. of Lettuce. | Wt. of Radishes. |
|---|---|---|---|
| 1 | None | 4.5 g. | 23.4 g. |
| 2 | Sludge | 6.3 g. | 63.0 g. |
| 3 | Extracted sludge | 6.8 g. | 68.0 g. |

The increase in weight, due to the sludge, is 40 per cent. in the lettuce, and 150 per cent. in the radishes. The radishes from the sludge pots when cut open and eaten were found to be very crisp and solid and to have a good flavor.

These pot cultures and gardening experiments show that the nitrogen in "activated sludge" is in a very available form and that activated sludge is valuable as a fertilizer.

The process is attracting a great deal of attention in America, and a very good statement concerning the work being done is given in *Engineering News* of July 15, 1915,* in which Mr. M. N. Baker has given an editorial review of the subject. The most extensive work is being done at Milwaukee. An article by Mr. T. Chalkley Hatton† gives a more complete account of the Milwaukee experiments. Two tanks of 1 x 5 x 10 ft. deep and one tank 10½ x 32 x 10 ft. deep have been operated on the fill-and-draw plan and one tank 10½ x 32 x 10 ft. deep is operated on the continuous plan. The Milwaukee Sewerage Commission has awarded contracts for the construction of a plant to treat 2 000-000 gal. of sewage per day by continuous flow. At Baltimore, they have been working on a small scale but have adapted two of the new Imhoff tanks for the use of this process and it is expected that in a short time they will be using activated sludge on a large scale. At Washington, the Hygienic Laboratory of the Public Health Service is experimenting on a small scale and is coöperating with the Department at Baltimore in their experiments. At Cleveland, experiments are being carried on in the sewage experiment station. They have adapted tanks 5 x 10 and 5 ft. deep which they used in their sewage experiments to the process, and while it has barely begun they are getting prom-

* *Eng. News*, 74, 164–171.

† *Eng. News*, 74, 134–137.

ising results. Experiments are to be carried out on a larger scale. At Regina, Saskatchewan, experiments on a considerable scale have been carried out, and their results are reported by R. O. Wynne-Roberts.* At Houston, Tex., they are planning to use the process in a plant to treat ultimately the sewage from 160 000 people. They do not expect to obtain complete nitrification, as a completely purified effluent is unnecessary. In Chicago, the Sanitary District of Chicago is using tanks about 2 ft. in diameter and 8 or 10 ft. high with quite satisfactory results, using the waste from the stock yards, one of the most difficult of wastes to treat.

At the University of Illinois four reinforced concrete tanks have been completed and put in operation. These tanks, operating on the fill-and-draw system, are designed for studying in a comparative manner the amount of air required, the best method for distributing the air, the time required for purification and the quantity and quality of activated sludge formed. The tanks are located in the basement of the power plant in a room which is not affected by heat from the boilers and where conditions are similar to those which would be obtained by housing a plant. The sewage is pumped to the tanks from city of Champaign main sewer by a 2 h.p. centrifugal pump run by a direct connected motor.

Each tank is 3.17 ft. square, giving an area of 10 sq. ft., and is 8.42 ft. in depth above $1\frac{1}{2}$-in. Filtros plates which are used for diffusing the air. In two tanks there are 9 plates, each 12 in. square, covering the entire floor. In the third tank there are 3 plates covering half the area of the floor, forming the bottom of a central trough. The remainder of the bottom slopes to the plates at an angle of 45 degrees. In the fourth tank is a single plate in the center covering one-ninth the area, with the bottom sloping to it at an angle of 45 degrees from all sides. Below the plates is an air space 4 in. deep. A petcock is provided to relieve the air pressure when draining the tank and to prevent air bubbles from rising and stirring up the sludge. The air obtained from the University compressed air plant at a pressure of 80 lbs. is reduced by a reducing valve to 8 lbs., and is further regulated

* *Canadian Engineer*, 29, 112, 113.

by a hand-operated valve before passing through meters on each tank. The pressure under which it enters the tank is sufficient only to overcome the pressure of the sewage and the friction of the plates, equivalent to about 8 ins. of mercury, or a little less than 4 lbs. per sq. in.

Two outlets for the effluent are respectively 2.5 ft. and 5.58 ft. above the porous plates. A tank can be filled in six minutes and drained to the lower outlet in eight minutes.

Experience has shown that a lower outlet connected to a floating outlet would be preferable. A fixed outlet is objectionable because sludge is at times drawn out with the effluent. In fact, no accurate data has been obtained concerning the quantity of sludge formed, because we have been unable to determine how much has been lost with the effluent. In order to prevent this loss, a floating outlet made of 2-in. pipe connected together with loose joints, has been placed in tank C. The effluent flows to the outlet through a screen of copper wire of about 16 mesh, which is fastened on both sides of an iron frame 1 ft. square. With this arrangement no sludge has been lost and we expect to obtain accurate data concerning the amount of sludge formed from the sewage.

The amount of sludge must be determined by weight on the dry basis, for it has been noted that its volume and rate of settling varies with the amount of air applied. If an unusually large amount of air has been applied, the sludge will settle more slowly and will occupy a much greater volume even after prolonged settlement than it does when less air has been applied.

*Building Up of Sludge.* — If, in accordance with previous practice, activated sludge is built up by complete nitrification of each portion of sewage added, it would require several weeks to put a plant in operation.

In order to obtain sludge more quickly, the English investigators have used sludge from sprinkling filters. At Milwaukee, Imhoff tank sludge has been aërated until it is aërobic and similar to activated sludge. Such a source of sludge would not be available in many places, especially at newly installed plants. We have attempted to shorten the period of sludge formation.

Tanks A and B were filled with the same kind of sewage on

May 5, 1915. The sewage in tank A was aërated continuously while the sewage in tank B was aërated twenty-three hours, allowed to settle, the supernatant liquid withdrawn and the tank refilled with fresh sewage in one hour. This cycle was repeated and determinations of the amount of sludge and of the degree of purification were made daily.

At the end of ten days, after one hour's settling in Imhoff cones, 1.0 per cent. of the volume in tank A consisted of sludge, while about 10 per cent. of the volume in tank B was sludge. The effluents from tank A, which had been aërated ten days, and from tank B, which had been aërated one day, were equally stable, while that from tank B was clearer.

Tank B was continued in operation, changing the sewage every twenty-four hours, until, after fifteen days, nitrification was complete. Then the sewage was changed every twelve hours and nitrification was again complete after eight days. Then the sewage was changed every six hours, but many of the effluents with the six-hour cycle were putrescible and it is necessary at intervals to aërate for longer periods. This comparison indicates, however, that sludge may be satisfactorily activated by changing the sewage before nitrification is completed, and that the sewage may be changed at frequent intervals.

Tank A was therefore cleaned and fresh sewage added every twelve hours. The stable effluents were obtained in seven days, and complete nitrification occurred in eighteen days, after which the sewage was changed every six hours. The effluents obtained from the tanks during this six-hour cycle were not all stable, yet the average improvement was so great that the conclusion is reached that activated sludge may be built up by changing sewage at frequent intervals without complete nitrification of each dose of fresh sewage. A considerable degree of purification is also obtained from the beginning of the operation, and the time for building up adequate sludge for the process is cut down very decidedly. A later experiment with tank C showed that satisfactory activated sludge could be built upon a six-hour cycle.

*Diffusion Area Required.* — The bottom of tank C contains

3 sq. ft. of Filtros plates, as described above, while the bottom of tank D contains 1 sq. ft. These tanks were put in operation July 6 and the sewage was changed every six hours. There was a noticeable difference, tank C giving some stable effluents after five days, while tank D did not give stable effluents in eighteen days. The sludge from C was of good appearance, while that from D was not as flocculent and at times had a septic odor. During the comparative experiment an average of 450 cu. ft. of air per 400 gal. of sewage was used with tank C and 360 cu. ft. of sewage with tank D. The amount of air given tank D was always sufficient to keep the sludge mixed with the sewage. In fact, the sewage in tank D was agitated much more violently than that in tank C. We have concluded that 1 sq. ft. of Filtros plate per 10 sq. ft. of floor area is hardly sufficient. Of the four tanks, tank C, with 3 sq. ft. of Filtros plate per 10 sq. ft. of floor area, has given the best results.

We have noted that it is quite essential that the plates be as nearly as possible at the same level as a variation of $\frac{1}{4}$ in. in level will cause uneven air distribution. The distribution seems to become more uniform the longer the plates are used.

*Quality of Effluents.* — The quality of the effluents has usually depended more on the strength of the raw sewage than upon any other variable. The tanks, when operating on a six-hour cycle, were filled at 9 A.M., 3 P.M., 9 P.M. and 3 A.M. The strength of the raw sewage, estimated by the ammonia nitrogen values, averages for the 9 A.M. sewage between 20 and 35 parts per million, and for the 3 A.M. sewage between 3 and 12 parts per million. Nearly all of the 3 A.M. sewages have given stable effluents, but the strong morning sewages have quite frequently given putrescible effluents. Unless the sludge is in good condition and well nitrified, a strong sewage cannot always be purified in four and one-half hours even by increasing the air to 800 cu. ft. per 400 gal. In the normal working of the plant the sludge will usually regain its "activity" if 800 cu. ft. of air is applied for several periods after the strong sewage has been added.

At times, however, with a succession of strong sewages, it is necessary to increase the period of aëration in order to obtain good effluents. Ardern and Lockett* noted in their first paper that, if the aëration was stopped before the sewage was well nitrified, the activity of the sludge would be inhibited. When strong sewages are to be treated, a definite cycle of operation cannot be established without provision for longer aëration of the sewage or separate aëration of the sludge. In order to keep the sludge in its most active state, complete nitrification of each sewage is necessary. Effluents are usually stable if 50 per cent. of the free ammonia is removed and 2 to 3 parts per million of nitrogen as nitrates are present.

The greatest efficiency in air consumption will be obtained when enough air is used to make the sewage non-putrescible and to keep the sludge activated. The operation of the plant during six months has suggested the advisability of studying more carefully such other features of the process as the amount of sludge formed, the building up of nitrogen in the sludge, and the composition of the effluent gases.

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* Jour. Soc. Chem. Ind., *33*, 623–639.

Vol. III APRIL, 1916 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PAPERS AND DISCUSSIONS



## SERVICE FOR THE SOCIETY.

By Edmund M. Blake,* Member Boston Society of Civil Engineers.

The building of a battleship depends upon the correlated service of every one engaged upon its construction, from the designer and template maker down to the man who heats the rivets that go in the hull. This service takes a multitude of forms, but is all guided toward that supreme moment when hawsers are loosed and the mighty hull slides down the ways at the launching. The completion of the structure, the perfection of details and the armament of the powerful fighting machine follow. Then come the tests, the acceptance and the placing in commission. The ultimate success of the battleship depends upon every detail of its design, the quality of every piece of material entering into its construction and the efficiency of the skilled and unskilled labor employed in its fabrication. The keynote is quality, whether in design, material or workmanship.

The building up of an engineering society as well depends upon the correlated service of every member. Application for membership and its acceptance should carry with it not only the willingness to give, but the intention of giving service. We who are following the greatest profession in the world have

Note. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the Journal.

* Civil Engineer, Brookline Mass.

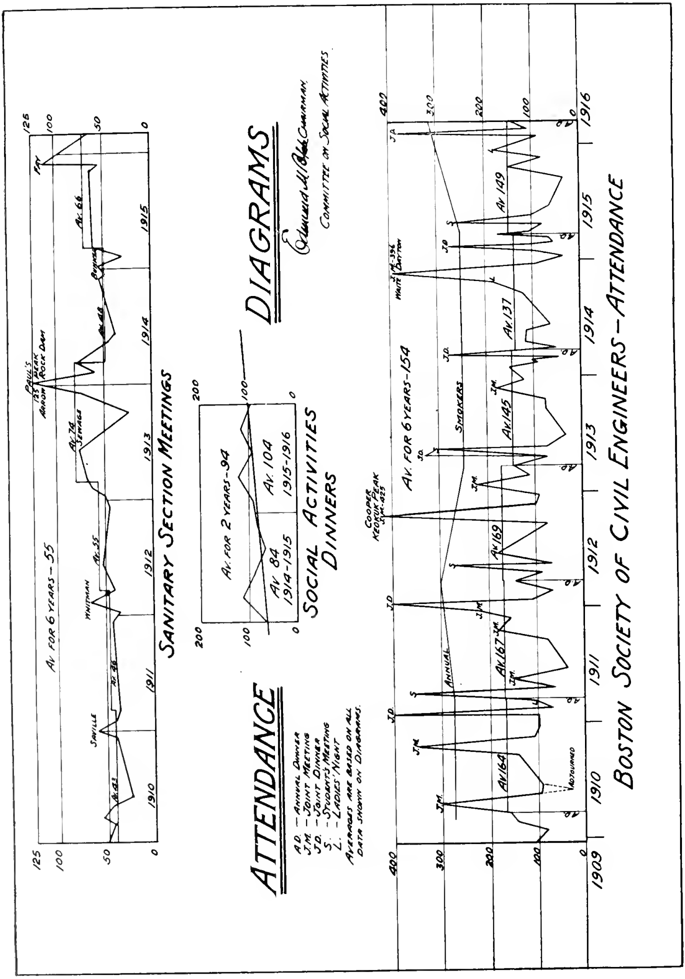
adopted engineering as our life work only after careful thought, deep consideration of all the branches of life's activities and usually a long scientific or practical preparation. If we are not loyal to engineering as the profession we have ourselves chosen, we should abandon it at once. If we are loyal to it, then the upbuilding and strengthening of our chosen profession should be one of the primary motives of our work. We cannot draw from a bank unless we have put in something to draw upon, and the more we put in the more we can draw out. It is equally true of the engineering profession. We must invest in it all we have, constantly adding to that investment as the years go by, if we are to share in the full returns.

An engineering society represents a coöperative effort by the engineering profession to consolidate its members into a concrete and united organization for the upbuilding and strengthening of the profession, for the benefits of personal contact and professional interchange of engineering knowledge, ideas and advice, for the purpose of commanding a broader recognition and a higher valuation of the engineering profession by the public, and for the publication and dissemination of the best in engineering theory, design and practice and the compilation of data. The individual member should be instilled with a true spirit of service, with an ambition to contribute toward the accomplishment of these purposes more than his share, and with a very clear realization that his application for membership in the society is not accepted primarily as adding one more wheel unit to the installation, but rather in the nature of additional second-feet of flow to be credited to plant capacity.

With this conception firmly established in his mind, the engineer who joins the society will consider of first importance the question of what he can add to the society and not of what he can get out of the society in return for his annual dues. Service for the society will follow, and soon there will be no need of arguing the other side, — that of the benefits to be received from membership in the society. This conception will not foster any false valuation of present personal contribution to the society, but rather will create an ambition to make the net final contribution represent the maximum possible individual output, always remembering that the engineering society is the one great concrete medium of contribution to the engineering profession.

The Boston Society of Civil Engineers was founded in 1848, and is the oldest engineering society in the United States. Its membership comprises those interested in mechanical and electrical as well as in civil engineering, and its officers have included prominent members of all three branches of the profession. To-day, its total active membership has reached one thousand, composed of members, junior and associate members and honorary members, and it has established a permanent and safely invested fund of over thirty-seven thousand dollars. It seems, to use an inadequate simile, like a big battleship ready for launching, but that does not mean necessarily a membership limited to one thousand with a waiting list, nor a permanent fund of only thirty-seven thousand dollars, nor in any way a reflection adversely upon the net result of past efforts, but rather the highest commendation for the achievements and distinction already won. The Society is now sixty-eight years old. Many of its present members may not answer the one hundredth anniversary roll-call in 1948. It can never hope to approximate the membership total of the American Society of Civil Engineers, but in quality, solidity and scientific achievement, in service to the engineering profession, fraternal *esprit de corps* and its contribution to the engineering literature of the world, it is possible for the Boston Society of Civil Engineers to establish its claim as the foremost engineering society in the United States on or before its centennial anniversary in 1948. In the intervening years, the structure must be completed, the details perfected and the final armament installed, and always the keynote must be quality in design, material and workmanship. That is wherein lies the opportunity for service and accomplishment. The honor of the Society should be made the honor of its every member.

The expression of the will of the Society should be reflected in its Board of Government, and the membership should express its will openly and often. That points plainly to the first duty of every member, — attendance regularly at Society meetings and other functions unless prevented by urgent necessity. This means on the average only about thirteen evenings out of the


ATTENDANCE
DIAGRAMS
Committee on Social Activities
A.D. – Annual Dinner
J.M. – Joint Meeting
J.D. – Joint Dinner
S. – Student's Meeting
L. – Ladies' Night
Averages are based on all data shown on Diagrams.
Sanitary Section Meetings
Av. for 6 years – 55
Social Activities Dinners
Av. for 2 years – 94
Av. 84 1914-1915
Av. 104 1915-1916
Boston Society of Civil Engineers – Attendance
Av. for 6 years – 154
Av. 164
Av. 167
Av. 169
Av. 145
Av. 137
Av. 149
Smokers
Annual
Adjourned
1909
1910
1911
1912
1913
1914
1915
1916

year, or probably not more than 52 hours out of 8 760 hours in the year, which is only about one half of one per cent. of a man's entire time. Attendance will result in knowledge of the *modus vivendi* of the Society, in transactions of Society business that more nearly represent the best judgment of the greatest number of members, and eventually will bring about those changes which must inevitably accompany advance and progress. There is no reason why any society should be controlled by a relatively small clique or group of members, but if the membership does not attend the business meetings, the society must be controlled by some small group that does attend. So the value and importance of attendance becomes evident and is very great, and it will soon transform outside criticism by members into inside effort to bring about synchronous and harmonious progress.

Certain diagrams are appended to this article with the intention of giving information. They do not, perhaps, have any direct bearing upon the matter under consideration. These diagrams give a graphical analysis of the actual attendance at the various functions of the Boston Society of Civil Engineers since 1909. The points plotted are taken from the published reports of annual meetings, and the attendance thus shown includes members and guests as well as members of the Boston branches of Mechanical and Electrical Engineers at joint meetings. The averages are calculated from the figures represented by all of the plotted points. The number of functions each year is shown by the number of points plotted. The records of attendance for the Sanitary Section and the social activities dinners are also shown in diagrams.

The main Society diagram shows an average attendance of 154 at the meetings plotted, covering the period of six years from March, 1910, to March, 1916. While exact data are not available, it is not likely that the average attendance of members for this period exceeded 100, and probably 80 would be more nearly correct. This is in the nature of a guess, as it is not feasible to determine the exact number of members present at the various functions of the Society without a standing count or roll-call, and this has never been undertaken. The diagram shows

80 meetings in six years, or an average of about 13 each year. The total membership of the Society during this period has been as follows:

| Year. | Membership. | Annual Increase. |
|---|---|---|
| In March, 1910. | 723 | . |
| In March, 1911. | 797 | 74 |
| In March, 1912. | 806 | 9 |
| In March, 1913. | 823 | 17 |
| In March, 1914. | 837 | 14 |
| In March, 1915. | 828 | 91 |
| In March, 1916. | 999 | 71 |

The average total membership has been 845, with an average annual increase of 46 members. If the larger figure of 100 for the average attendance of members is taken, it will be seen that the total number of members attending the meetings of the average year has been 1 300, which represents an average of less than two meetings attended by each unit of the average total membership of the Society.

There would appear to be no valid reason why nearly every member of the Boston Society of Civil Engineers should not find it possible to attend at least one half of the ten regular monthly meetings of the Society year. It even seems to be a matter of duty and loyalty. Such an attendance would have a far-reaching effect upon the progress and development of the Society. Allowing for non-resident membership absences and absences for other valid reasons, this would mean a total attendance of members at the meetings for the coming year of over 4 000, against an average of about 1 300 for the past six years. Even an indifferent consideration of this possibility should lead every member to do his duty during the Society year of 1916–1917.

The diagram of social activities dinners, with its average attendance of 94 for the past two years, largely of members, is simply a graphic demonstration that social functions of that nature supplied an unvoiced demand of the Society and met with instant response. The results have been most gratifying, and the effect upon the *esprit de corps* of the Society most beneficial.

The diagram of Sanitary Section meetings shows an average attendance of 55 for the six-year period, largely of members, which is probably more than 50 per cent. of the average attendance of members at the meetings of the main Society for the same period. It is a strong right arm of the Society, and its development as a specialized branch should be fostered by the main Society, while the members of the Sanitary Section should not overlook their obligations to the main Society.

It is hoped that these diagrams may prove of interest. Their lesson and the message of this article is that the best and highest interests of the Boston Society of Civil Engineers in the immediate future will be fostered and strengthened by a steadily increasing attendance of members at all of its functions, but especially at its regular meetings where business is transacted and professional papers are presented with an opportunity for public discussion. A large responsibility in bringing about this result will rest naturally with the Committee on Papers and Program, but a loyal response must be made by the members, and it is primarily by attendance at regular meetings that each member can best render his service for the Society. Thus the internal growth of the Society will undergo a wonderful development, its recognition and valuation by the public will be increased tenfold, and the standing of the engineering profession in the community will reach a high level never before attained. Meanwhile applications for membership will become more spontaneous with a rising standard of qualification. Finally, if the Permanent Fund is increased and invested on the present basis only, a sum probably exceeding $115 000 should be available by 1945, which would make it possible to celebrate the 1948 Centennial Anniversary in a new building owned and occupied by the Boston Society of Civil Engineers which would be a monument to those who had labored for its attainment and a pride to all future generations of its members. The fulfillment of this prophecy is not impossible. It will depend upon individual service for the Society.

Vol. III MAY, 1916 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

# THE CONSTRUCTION OF THE DORCHESTER TUNNELS UNDER FORT POINT CHANNEL.

By A. A. Cohill.*

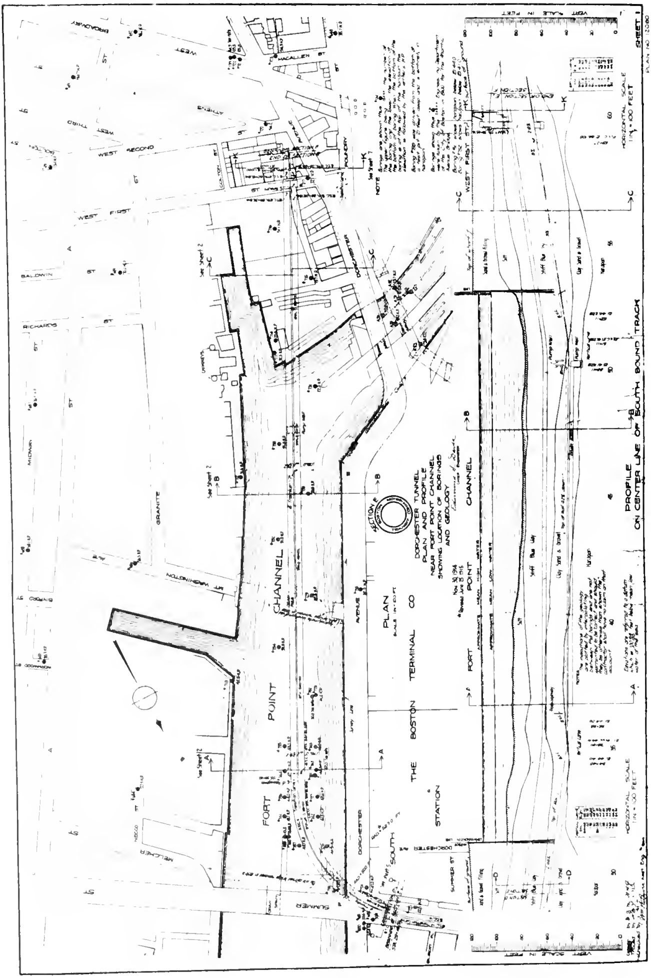
(Presented December 15, 1915.)

In presenting this paper on the construction of the Dorchester Tunnels under Fort Point Channel, I shall begin with the shaft upon which work was started on January 6 of this year by Patrick McGovern & Co., contractors for the work. This shaft is located on First Street, near Dorchester Avenue, South Boston. The tunnels are being driven in a northerly direction beneath the body of water known as Fort Point Channel to a point where they join with subway work just completed by the Hugh Nawn Contracting Company near the side entrance to South Station, Summer Street, Boston.

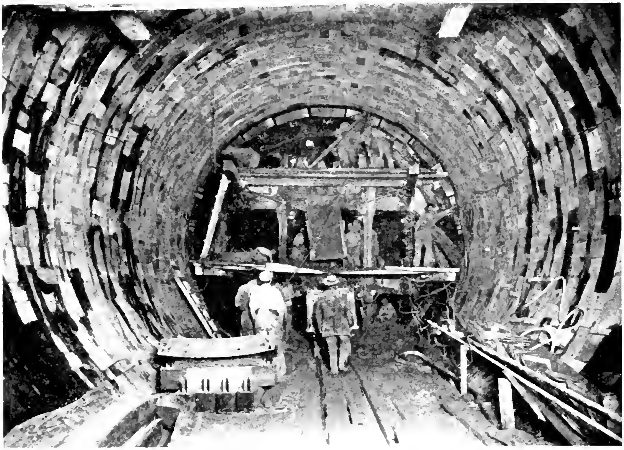
The shield, which is of the circular type with an outside diameter of 24 ft., has twenty-four hydraulic jacks, with eight additional jacks for table movement upon which a light pressure is maintained at all times, causing the platforms to move forward and support the breast or heading. The twenty-four hydraulic jacks are located in the tail of the shield and they engage the completed tunnel in such a manner that when the hydraulic

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the Journal.

* Chief Engineer, P. McGovern & Co., Boston.


DORCHESTER TUNNEL
PLAN AND PROFILE
NEAR FORT POINT CHANNEL
SHOWING LOCATION OF BORINGS
AND GEOLOGY
FORT POINT CHANNEL
PLAN
THE BOSTON TERMINAL CO
SOUTH STATION
PROFILE
ON CENTER LINE OF SOUTH BOUND TRACK
HORIZONTAL SCALE
VERT SCALE IN FEET
SHEET 1
WEST FIRST ST
WEST SECOND
WEST THIRD
BROADWAY
BALDWIN
RICHARDS
GRANITE
SUMMER
DORCHESTER
MELCHER
FOUNDRY

pressure is applied, the shield is moved forward a distance of 30 in., which is termed "a shove," and the building in of two sets of wood segments, or, in other words, two rings, is permitted. The maximum pressure in the jacks is 5 000 lbs. and the average 3 500 lbs. to the square inch, or 75 tons to the jack. It requires sixteen segments and one short block, which is called a key, to build a ring. The segments are something over 4 ft. in length,



DORCHESTER TUNNEL, SECTION E. SHIELD AND WOOD TUNNEL LINING.

and square about 10 in. They are held in place by steel pins forced into them by the shield jacks. We get about nine shoves every twenty-four hours, the excavation, of course, being carried on from the various decks in the shield without interruption.

These tunnels are subaqueous, and, as was anticipated, we found it necessary to put the headings under air pressure when they had reached a point about 200 ft. away from the shaft. The building of the necessary bulkheads and the installation of the locks was quickly done, and the air was first turned into the headings at a pressure of 25 lbs.

*Air Locks.*

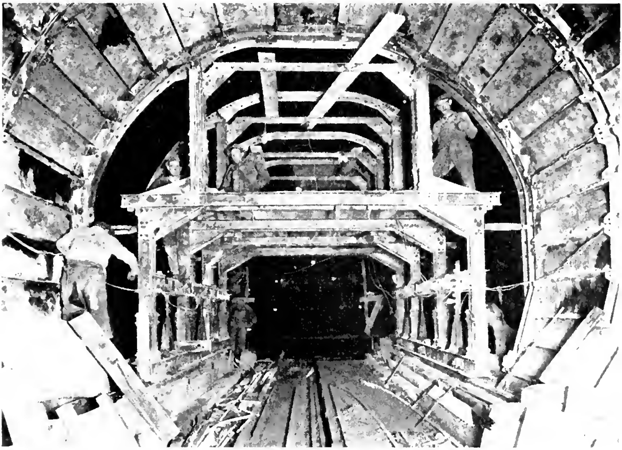
The material locks, two in each tunnel, are interestingly large, being 7.5 ft. in diameter. The man or emergency lock in each tunnel is located directly above the material locks and will conveniently accommodate from thirty-five to forty men. As the work progressed and we became more familiar with the conditions, we lowered the pressure of air to 18 lbs. per sq. in., and later raised it to 20 lbs. when at a point directly under the channel. This is the air pressure now carried.

It might be interesting to you if I should say something about the effect of compressed air upon the workmen. About one of the first things one hears much of are the "bends." I will leave it to the medical fraternity to explain just what is meant by the term "bends." I will say, however, that we have had some of our laborers incapacitated by the effects of the compressed air. This seems to occur more frequently after the pressure has reached a point over 22 lbs., and in nearly every case I investigated, I found the disablement was brought about through some indiscretion on the part of the individual affected. Decompressing too quickly accounts for much of the trouble, and the change of temperature without proper clothing, which is common among the workmen, is bound also to give trouble.

A cross section of the tubes would show the following construction employed. First the wooden ring made up of the long-leaf yellow pine segments and key, then the waterproofing of three-ply Minwax cloth well mopped with hot asphaltum, then the inner lining of concrete at a minimum thickness of 2 ft.

After the shield has been moved forward and the rings placed, there is a space between the material through which the shield is passing, and the outer skin of the tunnel. This space is filled with a mixture of sand and cement ejected through holes bored in the wooden lining. We have been using a pressure of about 45 lbs. for the ejection of this grout.

The concrete arch and side walls are molded with steel forms made up of plates and angles in sections of 15 ft. with plate subsections of 5 ft. each. These subsection plates can be removed so that the concrete may be placed behind the forms at any desired elevation. One 15-ft. section of the form is transported by a large gantry or carrier. After this section has been lowered into position, the gantry is collapsed and moved backward through the tunnel, to be used in bringing forward another set of forms. This operation is repeated over and over each twenty-four hours. The rail supporting the carrier is laid along the duct steps on either side of the invert. The work of laying



Dorchester Tunnel, Section E. Steel Forms and Traveler, looking in from Shaft.

the concrete invert is carried along in advance of the arch and side wall construction.

There are several features in connection with the construction of these tunnels to which I wish to call particular attention. The system as worked out by Mr. McGovern and Mr. Charles R. Gow, the able President of your Society, and consulting engineer for the contractors, allows muck to be handled through all other work to cars in the completed tunnel. It permits the concreting of invert, the waterproofing of both invert and arch, the placing of the wood lining and the concreting of arch. Each one of these individual operations can be carried along with full crews during each twenty-four hours. The contributing factors to this system are a belt conveyor and a platform which is outrigged from the back of the shield.

This conveyor is about 100 ft. long, and is attached to the shield and moves along as the shield advances. The structure carrying the belt and its appurtenances, as well as the motor and hoppers, is mounted on wheels, which roll along a narrow-gage track that becomes one of the material tracks. To one side of this conveyor the muck cars are placed, and the muck, as shoveled from the different decks of the shield on to the rubber belt is discharged into these cars at a point well back on the completed invert and just forward of the arch and side wall construction.

The platform, which is attached to the shield and from which we do our grouting, place our wooden segments and store all the material to be used in each move, is supported by two H-beams of 15-in., 100-lb. section, with raker rods with turnbuckles for adjustment. The arrangement of this platform permits waterproofing the invert, the grouting and the lining with wood blocks to be carried on simultaneously without interference.

There are several interesting details in connection with the shaft on First Street which are worthy of mention. There are two elevators delivering the tunnel cars to a gantry well above the level of First Street, and without any interference to public travel. When the tunnel cars reach the top of this gantry, they are dumped through hoppers into 4-yd., narrow-gage cars, which are always in waiting, and are in turn hauled over a two-track elevated structure to a terminal dock on Fort Point Channel, where scows come alongside to receive the muck, and to discharge the yellow pine segments used for building the outside skin of the tunnel.

*Power House.*

The compressing machinery, electrical equipment, machine and blacksmith shop are located here. There are in this plant four boilers each of 150 h.p. capacity, two low-pressure Sullivan compressors, one high-pressure Sullivan and two high-pressure Ingersol-Sargent compressors, two General Electric generators of

50 kw. each, the necessary hydraulic pumps, condensers, etc. The Sullivan compressors have a capacity of about 2 200 cu. ft. of free air per minute.

If you should attempt to follow out the sequence of our work, you would find many little changes and innovations.

The first one I wish to call attention to is the conveyor. We originally had a long ramp or incline, for it was our intention, and for a while we had it in operation, to draw the concrete cars up this incline and along the track over the conveyor belt to the deck of the concrete form carrier. This was not a success, and we very quickly did away with that portion of the conveyor frame. I allude to this to show the trials the contractor is put to in endeavoring to make the plant fit the conditions. To take the place of this ramp or incline, we installed a platform carriage or traveler similar in manner to that which handles the concrete forms, and with it an elevator which is operated by a two-drum hoist run by compressed air. The concrete is brought into the tunnel in 1½-yd. concrete cars, which are on the forward part of the train as it moves down the tunnel. These cars are delivered to the elevator, hoisted to the deck of the gantry, rolled from that point to the deck of the concrete form carrier and dumped. From this point the concrete is placed behind steel forms.

It was our original intention to have three operating tracks the entire length of the tunnel, giving the center track over to the concrete delivery alone, and allowing the muck cars or a muck train to stand on either side of the conveyor, and then with the aid of a deflection table, discharge the muck on either side. This had to be given up for a lack of clearance between the sides of the invert. While these changes were slight, for a time they had considerable bearing on the progress of the work.

While speaking of progress I would say that our best month's run in one tube was 375 ft. This means 375 ft. of completed tunnel. Our average run for the best three months was 325 ft. per month, a goodly portion of this being in hard pan, which accounts for the slowdown and difference as shown for one month. I think I am safe in saying this establishes a record for subaqueous tunnel driving. Every cubic foot of material in the heading had to be brought through the shield and out of the locks.

When the air pressure was first placed on the tunnels, which was early in June, we did not consider it necessary to make any provisions for cooling the air, but we found this was a problem that would have to be reckoned with, and we were not very long installing after-coolers. There is nothing new about after-coolers, but there are different designs, and I think it might be interesting for you to know something about the cooler we are using. It is about 3 ft. in diameter, and 12 ft. long, with about one hundred and twenty 1½-in. brass tubes through which harbor water is pumped. As the air leaves the compressor it passes into the after-cooler, where it is expanded and cooled and then carried on to the heading through an 8-in. steel pipe. At the discharge end of this pipe, the air is practically dry. We have experienced no trouble whatever from carbon dioxide. It is safe to say you will find the temperature of the air at the discharge end of the after-cooler about 15 degrees higher than the temperature of the water that is being used to cool it. To-day we had a temperature of 187 degrees at the compressor end of the after-cooler, and a temperature of 65 degrees at the discharge end, with a harbor temperature of 50 degrees. The tunnel temperature was about 72. This difference of 7 degrees might be accounted for by friction produced in the pipe, as well as by a reducer that caused back pressure, and the fact that the temperature readings at the after-cooler were taken in the morning, and the tunnel temperature in the afternoon. For the benefit of those interested in plant installation I will say that the Sullivan compressors which are installed in the power house are all high-pressure machines. Our object in using this type was that for a small expense the inter-coolers could be replaced at any time, and from a standpoint of salvage, these machines could be sold more readily on account of the demand greater for high-pressure than for low-pressure compressors.

*Hospital and Hospital Lock.*

About the time we placed the air on the tunnels, we installed a hospital lock which is located in the power house. We found it advantageous to have this, and have treated a few cases of "bends." We have a small room fitted up near the shaft, with a graduate nurse in daily attendance, where accidents of a minor nature are taken care of. We have fitted up a well-lighted, well-heated hog-house, equipped with showers and plenty of locker room, where the men are given hot coffee at any time during the day or night. These quarters are well cared for, as the efficiency of the workmen is a matter of important consideration.

*Concrete Mixing Plant.*

Just south of First Street, directly alongside of our shaft, we installed the concrete mixing plant; by simply putting in the side walls in that portion of the tunnel we are building south toward Broadway, and leaving out the arch, we took enough available space to install sand bins. The tops of these bins are on the same level as First Street, which permits the motor trucks and teams drawing sand and stone to dump their loads directly into the bins. At a point sufficiently high above the tunnel invert to permit a concrete car being pushed under it, the concrete mixer is located. The cement shed is also located on a level with First Street, and the cement in bags is passed down to the mixer through a spiral chute. This gives us a gravity mixing plant which is operated very economically.

The material encountered in the heading up to the present consists chiefly of clay, with an occasional streak of sand. This clay stands up well under 20 lbs. pressure of air, but without the air it flows freely. We have just begun to encounter a mixture of sand, gravel and clay (hardpan) and now and then a bowlder. This underlies the clay and is gradually rising in the face of the shield. We have found it advantageous at times to use explosives, employing very light charges of 20 per cent. dynamite. This is loaded in four cut-off holes, directly in front of the bottom cutting edge of the shield, and in four breakdowns just above the first deck of the shield.

The amount of air escaping through the heading up to the present time is *nil*. We are supplying to the two tubes about 1 900 cu. ft. of free air per minute, which is not quite the capacity of one of our large machines. The ventilation is good.

The constant operating of the locks provides the tunnel with very good circulation. We experience no bad effects whatever from the smoke produced by the dynamite.

*Waterproofing.*

It was thought at one time that the efficiency of the men might be impaired by the fumes arising from the hot asphaltum which is used in connection with the waterproofing. This was, of course, before we had used any. There has been no time when we have had any trouble from this source.

The work of constructing these tunnels is being done for the Boston Transit Commission, of which George F. Swain is chairman, Edmund S. Davis, chief engineer, and G. D. Emerson, assistant engineer in direct charge of this and adjoining subway sections.

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

# PAPERS AND DISCUSSIONS

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## THE RECONSTRUCTION OF THE MUNICIPAL WATER WORKS, CAMBRIDGE, OHIO.

By W. J. Sherman,* M. Am. Soc. C. E.

(Presented before the Sanitary Section, February 2, 1916.)

The municipality of Cambridge, Ohio, founded in 1806 by Guernseyites, is commendably ambitious and justly proud: ambitious to develop and grow, and proud of its name, its record and its prospects. It aspires to be the greatest manufacturing city of its state, and claims to have the cheapest fuel, due to the proximity of about two dozen mines, producing a high-grade bituminous coal.

The last census gave Cambridge a population of 11 327. These figures were disappointing to the public-spirited citizens, who suggested a mistake on the part of the census-taker, and raised the question, "Why take the census at all, for it is so often disappointing?" Others said Cambridge would undoubtedly have made a better showing had she been provided with a bountiful supply of pure and wholesome water, and this undoubtedly is true, but the proof of it will not be forthcoming until after the census of 1920.

Cambridge has financed and is building a $250 000 im-

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the Journal.

* Of the W. J. Sherman Co., Consulting Engineers, Toledo, Ohio.

provement to, or perhaps we had better say, reconstruction of, the water-works system.

## The Existing Water Works.

The water works, which are municipally owned, were installed in 1896, a supply being taken from Wills Creek without filtration, and about eight miles of pipe lines being laid. The original cost is said to have been $63 000. There are now about 15½ miles of cast-iron pipe in the distribution system, varying from 14 ins. to 4 ins. in diameter, more than 75 per cent. of it being 4-in. and 6-in. pipe. There is a standpipe of 200 000 gal. capacity supplying the domestic service. The two 1 500 000-gal. compound duplex pumps of the original installation are still in service, and a 2 000 000-gal. pump of similar design purchased at a later date is out of commission.

The water consumption is reported as having a range from 1 000 000 to 1 400 000 gals. per day, and an average of about 1 200 000 gals. There are 2 200 services producing gross earnings of about $7.00 per service, the quality of the water furnished not warranting rates fair to the city For example, $5.00 per annum pays for all the water used by an ordinary family, including bath and closet.

The source of supply is Wills Creek, a very considerable stream draining over 300 sq. miles above the city. The slope of the stream bed is flat and the normal flow is sluggish. Occasional excessive turbidity prevents the use of meters, and none have been installed. As the stream is polluted by the twenty-six coal mines and several villages within the drainage basin, there have been numerous attempts to obtain a ground water supply, but they were unsuccessful, and so this municipally owned plant has furnished the people of Cambridge with water which was always dangerous though sometimes clear and sparkling. It is reported that the volume of flow in Wills Creek has on one or more occasions been reduced to a dangerously small amount near the end of some protracted drought. Moreover, the pumping station was small and the machinery utterly inadequate to meet the requirements, the normal station pressure of 100 lbs. in the bottom lands being insufficient for the needs on the hills.

## The Efforts to Improve Conditions.

It is doubtless true that Cambridge could not develop along the lines of her ambitions unless something was done to improve both the quantity and the quality of the water supply. Nor should we overlook the serious need for reinforcing and extending the distribution system into the outlying districts of the city. The problem at Cambridge was, therefore, one of reconstruction rather than of mere improvement.

While thoughtful citizens have been aware for a long time that something would have to be done to improve conditions, yet it seems to have required the added stimulus of the State Board of Health to produce results. More than fifteen years ago the State Board warned Cambridge of the dangers of impure water and the necessity of providing a source other than the raw water of Wills Creek, and the records of the board show frequent reference to Cambridge, her unsatisfactory water supply, and the need of improving it. At times the water has been so bad that even animals refused to drink it.

The public early resorted to surface wells for drinking water, thinking it safer because clearer. But there was much typhoid, and frequent analyses of well waters and hydrant water were made to determine their relative safety.

Late in 1899 the city, with the approval of the State Board of Health, abandoned Wills Creek as a source of supply in favor of one from wells pumped with air, which seemed promising, ten wells 110 to 125 ft. in depth having been drilled and provided with a large receiving well. For a time it appeared that the problem of a satisfactory supply was solved, but this and other similar efforts seem to have failed, for in 1903 the statement was made by the State Board of Health, that "the hydrant water has not improved with use, and though still preferable to the waters of Wills Creek, the analysis shows it undesirable." Shortly after this the well supply was abandoned in favor of the creek supply, which is still being used.

Commenting on the analyses made in 1905, the State Report says:

"The results are, in general, similar to those obtained from Wills Creek near the water-works inlet in 1899. These findings show a surface water containing considerable vegetative organic matter, a slight amount of sewage material, and much suspended matter. From previous analysis this is such a water as may be expected from Wills Creek at any time, although there are seasons when it is much worse. It is a water that is wholly unfit for a public supply in its present untreated condition."

It would thus appear that as long ago as 1905 the filtration of the public water supply was under consideration. All efforts to obtain an abundant supply from deep wells had failed, and the quality of the water from shallow wells was similar to that obtained direct from the creek, and the quantity was not nearly so great.

It is one thing to determine the needs of a young and growing city and quite another to finance them within the allowable limits of taxation. This financial problem is, in fact, a much greater problem in most cases than the engineering problem of planning and designing.

Cambridge has been struggling with the financial problem for a long time, and even to-day it is not the least of her troubles. None of her departments has ever been self-supporting, and the earnings of the water department have always been disappointing, ranging as they have for years a little over one dollar per capita exclusive of the public service, which pays nothing, instead of about three dollars as they should if good service were rendered. It has always been the writer's conviction that a municipality should credit its own plant with the same amounts they would have to pay a private company for fire protection, sewer flushing, street cleaning and similar service, for a public plant is entitled to the same fair treatment which a private plant demands and obtains.

In 1909 the State Board of Health recorded the fact that the city of Cambridge had "presented satisfactory evidence to show that said city is unable financially to pay for the installation of sewage purification works and remove the cause of complaints and to install a new public water supply." So sewage purification was postponed, "provided the authorities of the city of Cambridge take the necessary measures to secure the introduction of a satisfactory public water supply without delay."

This was in January, 1909. In June, 1910, the State Board made the formal request that the city "engage the services of a competent consulting engineer to prepare plans and specifications for storage facilities, purification works and all necessary adjuncts involved in an improvement of the present water supply to an extent that will render it safe from a sanitary point of view, and will remove all objectionable physical characteristics." The project was to be completed, according to the plans officially approved, at a date not later than May 1, 1911, or in default thereof the State Board of Health would proceed according to the provisions of the so-called Bense Act, passed April 7, 1908.

Under a mistaken impression as to the probable cost of the project, the city administration on two occasions, in May and June, 1912, submitted the question of bond issues of $75 000 and $100 000, respectively, to the people for vote. Both failed and resulted in a mandatory order from the State Board of Health in June, 1913, to install a satisfactory water supply prior to January 1, 1915. This order was approved by the governor and the attorney-general and is now being carried out at an estimated cost of $250 000. In August, 1915, the State Board of Health extended the time for completion to February 6, 1916.

The praiseworthy efforts of the State Board of Health looking to a betterment of the sanitary conditions of the numerous municipalities of the state had often been defeated because it had not sufficient authority properly to enforce its suggestions, requests and orders. It became increasingly apparent that the Board could not properly perform the functions for which it was created without additional legislation designed to materially increase its powers, and, through the efforts of the friends of good government, the so-called "Bense Act" was passed by the legislature on April 7, 1908. This act was entitled, "An Act to authorize the State Board of Health to require the purification of sewage and public water supply and to protect streams against pollution," and it authorized the Board to take definite action to prevent the pollution of streams and to compel public and private corporations to furnish consumers a bountiful supply of pure and wholesome water.

Some of the provisions of this act were deemed unconstitutional, resulting in litigation which was carried through the common pleas and circuit courts to a final decision in the supreme court of the state. The decision was handed down in April, 1912, in the case of "The State Board of Health *v.* The City of Greenville," and its effect sustained the constitutionality of the so-called "Bense Act."

This Act gives the State Board of Health plenary powers, subject to the approval of the governor and attorney-general, over sewer outlets and water inlets and the construction and operation of the works necessary to purify both sewage and water. The right of appeal to a Board of Sanitary Engineers acting as referees is given the recipient of an order from the State Board of Health, and "such referee engineers may affirm, modify or reject the order of the State Board of Health submitted to them," and their decision shall be final. The bonds authorized to provide funds for carrying out the orders of the State Board of Health may not exceed five per cent. of the amount of the tax duplicate, and may be in addition to the total bonded indebtedness otherwise permitted by law, and the authority to issue need not be submitted to vote. Failure to carry out the orders of the State Board of Health subjects each offender to a fine of $500.

Because of the delays incident to the litigation referred to, the time limit of May 1, 1911, for completing the improvements at Cambridge expired without action by the city, and an extension of time until February 6, 1916, was given by the State Board of Health. Another extension until December 31, 1916, has been applied for.

In February, 1914, The W. J. Sherman Company was engaged as engineers, and in August, 1915, the entire improvement was placed under contract, construction operations now being in progress.

## The Engineering Problems.

The first problem to solve was, naturally, the quantity of water required. Then came the source from which to obtain it, followed by the question of purification or not, and if so, the method to be employed. Then came pumping station machinery, direct pressure or elevated reservoir, and finally the reinforcement and extension of the existing distribution system.

With a population of 10 569 in 1900 and 11 327 in 1910, it was deemed best to provide for a population of 30 000 and a water consumption of 3 000 000 gals. per day as the minimum requirements.

The problem of finding a source of supply proved to be the most difficult one encountered. All of Guernsey County is rough and hilly and located in the breaks of the Ohio River. The peaks are sharp and the valleys rather narrow, the former rising 300 to 400 ft. above the latter.

The search for a suitable reservoir site was diligent and thorough. One which would provide a gravity supply for the entire city was out of the question because the city itself occupies not only the entire valley of Wills Creek, but both hillsides nearly to the top. It was desirable to secure a location from which the supply would at least gravitate to the pumps in the city, and if filtration could be avoided it would be most fortunate. By far the most important consideration was the volume of supply available, this being controlled largely by the drainage area above the dam.

It is the writer's observation that in the past there have been many disappointments due to failing or insufficient water supplies. Many a reservoir has been entirely depleted, due to an insufficient drainage area; and many an underground supply has failed because of the gradual falling away of the ground water levels. Sometimes the fault lies with the engineer and sometimes with arbitrary city officials, but always the engineer is blamed; hence the importance of good, thorough engineering work and a public record for the protection of the engineer.

Among the reservoir sites examined and studied were the following:

| | Drainage Area. Sq. Miles. |
|---|---|
| Chapman's Run | 19.5 |
| Sarchet Run | 7.3 |
| Peters Creek | 9.9 |
| Crooked Creek | 62.0 |
| Buffalo Creek | 50.0 |
| Seneca Creek | 151.0 |
| Leatherwood Creek | 89.0 |
| Salt Fork | 163.0 |
| Board of Trade Run | 1.0 |

Since the great flood throughout the middle west in March, 1913, we have seen frequently the expression "dry reservoirs" in connection with the retention or detention of the excess of flood waters in special reservoirs, and their gradual release after all danger has passed. But there is another kind of "dry reservoir" which, instead of proving a blessing to the community possessing it, is occasionally a source of great distress. I refer to reservoirs intended for collecting and impounding water supplies for municipal use which become dry and go out of commission at times when they are most needed. There are many examples of this kind of "dry reservoirs" in America, especially in the territories subject to more or less prolonged droughts.

Statistics show that evaporation alone in the territory which includes Pittsburgh, Columbus and Cincinnati causes an average loss of about four feet per annum from reservoir surfaces. Then there are losses due to ground infiltration and dam leakage which must be anticipated and provided for in the original construction. That this has not always been done is evident from the number of reservoirs which at times fail to perform properly their functions throughout the entire dry season. Within fifty miles of Toledo there are at least two such cases, viz., at Norwalk and at Bucyrus, and it may be of interest and quite appropriate to submit some data covering these two reservoirs. Norwalk had a population, in 1910, of 7 858, and Bucyrus, 8 122. The reservoir at Norwalk impounds 500 000 000 gals. from a drainage area of 8.6 sq. miles, while the reservoir at Bucyrus impounds 155 000 000 gals. from a drainage area of 3.9 sq. miles. The water consumption is respectively 222 and 117 gals. per capita per day. As may be inferred, the former is a municipally owned and the latter a privately owned plant, and neither is metered.

In Ohio it has been demonstrated that a drainage area of one square mile will yield about 120 000 000 gals. per annum, and supply a population of 1 000 to 2 000 provided there be sufficient storage and ordinary restrictions on water consumption. It is manifest that the water shortage at Norwalk would cease with the introduction of meters, for both drainage area and storage capacity are otherwise ample. It is also manifest that at Bucyrus both drainage area and storage are insufficient.

The practical conclusions of our studies on the relative minimum requirements for drainage area and storage capacity for municipal water supplies in Ohio cities are that it is desirable to secure at least one square mile of drainage area per 1 000 population. A larger drainage area will permit of a smaller storage, and vice versa. In Ohio the minimum yield is assumed to be 25 per cent. of the minimum rainfall of 25 ins. per annum.

The minimum annual yield should be sufficient to anticipate a reasonable growth for, say, fifty years to come, but the engineer who is permitted by the authorities to plan so far ahead can be congratulated, for the cost must always be considered. The yield per square mile of catchment area was assumed for the Cambridge territory to be 25 per cent. of the precipitation for the two extremely dry years of 1894 and 1895, when 28.24 and 28.78 ins., respectively, fell in this district. This provided 123 and 125 million gallons per annum.

As already stated, the several available reservoir sites were each carefully studied with a view of determining their relative merits. By a process of elimination the number was finally reduced to three, viz., Salt Fork, Peters Creek and Board of Trade Run, and reports were made on all three projects.

It was developed in these reports that Salt Fork possessed greatest merit in available yield and permanent dependability, quality of water before treatment and safety of water after treatment, whereas the Board of Trade project had the merit of lowest initial cost, and Peters Creek that of lowest operating cost. It is proper to state here that Sarchet Run near by was available for a supplemental supply if and when required in the future.

The friendly controversy over reservoir sites between the friends of each was prolonged, with the engineers favoring Salt Fork, a very splendid project, though costing $150 000 more than the Board of Trade project and $25 000 more than Peters Creek.

For convenient comparison of the three projects the following statement is given:

RESERVOIR FEATURES.

| | Salt Fork. | Peters Creek. | Wills Creek and Board of Trade Run. |
|---|---|---|---|
| Drainage area........ | 163 sq. miles | 10.89 sq. miles | 300 sq. miles |
| Reservoir capacity in gallons............ | 500 000 000 | 700 000 000 | 212 000 000 |
| Distance from Court House............. | 6.5 miles | 4.1 miles | 1.5 miles |
| Area submerged....... | 145 acres | 191 acres | 36 acres |

The Salt Fork project, with a drainage area of 163 sq. miles, located in the back hill country with a total resident population of less than 1 000, free from mines, industrial establishments and railroads, and likely to remain so, was certainly an inviting proposition from an engineer's standpoint. But the immediate financial interests of the city prevailed, and the Board of Trade Run was finally selected.

The drainage basin of Wills Creek is larger, having an area of over 300 sq. miles. There is a resident population of about 20 000, and the basin contains numerous coal mines. The sources of pollution are rather numerous, and the water supplied the city from this source has always proved very unsatisfactory. The bottom lands are broad and largely under cultivation. The stream has a sluggish flow during normal and low stages.

There is no suitable location in the valley of Wills Creek and within a reasonable distance of Cambridge for a collecting reservoir. The flow of the stream was measured during the extremely low water of August 13, 1910, and found to be 1 320 000 gals. per day, and it is safe to say that it sometimes is as small as 1 000 000 gals. per day for brief periods.

It was early manifest that Wills Creek would afford a plentiful supply if provided with a storage reservoir of sufficient capacity, but no suitable location was available in the immediate valley of the creek. Fortunately, however, there was a splendid location for a reservoir a short distance above the city and less than 1½ miles from the existing pumping station.

It was known as the Board of Trade Run, well adapted by nature for a reservoir of practically any capacity desired, as the hills rise on three sides to a height of 400 ft. above the valley, and the dam at the foot of the valley, to afford a capacity of 212 000 000 gals., is but 500 ft. in length, with an extreme height of 50 ft. when the flow line is 60 ft. above the low waters of Wills Creek.

This was the reservoir site finally selected because of the low initial cost.

A reservoir capacity of 212 000 000 gals. was determined upon as being sufficient to carry the city for about four months of dry weather without replenishing from Wills Creek, from which must come practically the entire supply, as the drainage basin of the Board of Trade Run is but about one square mile.

On the banks of Wills Creek is being built an auxiliary pumping station designed to house duplicate motor-driven pumping units, each having a capacity of 2 100 gals. per minute, one for service and one for reserve. Distant control starting apparatus will be provided so that the motors can be operated from the control station 1½ miles away. A low dam is being built at the auxiliary pumping station to raise the general level of Wills Creek about three feet at the intake.

A 24-in. gravity line from the large reservoir to the central station is to supply the filters at that point. For economic reasons this low pressure (24 lbs.), slow velocity (1.5 ft. per sec.) gravity line is being constructed of cypress instead of cast iron, the engineer's favorite material. It is expected that these wood stave pipe will render good service for thirty or thirty-five years.

Under the plan finally adopted the water must be pumped three times before it finally enters the distributing system, first from Wills Creek unto the main storage reservoir, second from the coagulation basin into the filters, and third from the clear well to the mains. All this to reduce the initial cost of the installation!

Inasmuch as double pumping was unavoidable in any event if the water was to be filtered, it was reduced to either the gravity fill of a big reservoir 6 miles away or a pump fill of a smaller reservoir $1\frac{1}{2}$ miles away at an estimated saving of $150 000. While it is true that a richer and larger community would have selected the former site, yet in this instance it could not be accomplished, even though a saving in operating expenses of perhaps $1 000 per annum could be effected.

Included in the original plant was a brick settling basin having a capacity of 500 000 gals. This is hereafter to be used as a double unit coagulating basin in connection with new rapid sand filters of the gravity type which are being built over one end of it.

The present water consumption is about 1 500 000 gals. per day. The filters are in four units of 750 000 gals. per day each, one of which will be left blank for the present. Space allotments are as follows: Operating floor, 1 040 sq. ft.; pipe gallery underneath has same area; chemical room, 600 sq. ft.; pump and blower room, 325 sq. ft.; chemical storage, 925 sq. ft.

Water piping within the building will in general be cast-iron flange pipe, and all chemical piping will be of lead.

Each filter has an area of 264 sq. ft. The coagulant will be either sulphate of alumina or sulphate of iron with lime, and the filtered water will be treated with hypochlorite of lime. The filtering sand is to have an effective size of not less than 0.35 and not over 0.45 of a millimeter and a uniformity coefficient of not over 1.65. There will be 30 ins. of filter sand overlaying 9 ins. of gravel graded from No. 20 mesh up to 1 in. The strainers will be of brass with headers of cast iron and a separate manifold system.

The equipment includes rate controllers, loss of head gages, rate of flow gages and recording dials, hydraulically operated valves and marble top operating tables. The wash water pump is to have a capacity of 2 000 gals. per minute, and the blower a capacity of 1 060 cu. ft. of free air per minute at four pounds pressure.

The solution tanks will be of concrete with an orifice box for each tank. The guaranty requirements provide that filtered water shall contain no decomposed coagulant, shall be free from odor due to the chemicals used, and shall be bright, clear and free from color, turbidity or suspended matter visible to the eye.

The filtered water must show an average reduction of bacteria of not less than 98 per cent. when the number in raw water exceeds 3 000 per cubic centimeter and not more than 100 bacteria per cubic centimeter when the number in the raw water is less than 3 000 per cubic centimeter.

The clear well adjoining the filter plant is to have a present capacity of 210 000 gals. and an ultimate capacity of double that amount.

While the new pumping station will occupy the same site as the old one, the entire station will be reconstructed, providing a new brick stack (54 ins. by 110 ft.), brick building, gravity coal chute, two 3 000 000 gal. cross compound, crank and fly wheel pumping engines and one 150 h.-p. boiler.

The pumping engine while delivering 2 100 gals. per minute against a pressure of 150 lbs. is required to develop a duty of not less than 135 000 000 foot-pounds and a half-speed duty of not less than 100 000 000 foot-pounds per 1 000 lbs. of dry steam.

American Water Works Association Class C pipe is being used throughout, in the construction of the 10 miles of new mains, to reinforce and extend the distribution system. All pipe laid is tested to 175 lbs., and all leaks stopped before the trenches are backfilled.

The speaker is deeply impressed with the great importance of this requirement and the fact that engineers seldom enforce it. The result is a continuous leakage and waste which cannot be accounted for, amounting in some instances to as high as 25 per cent. of the total pumpage.

The plant, while possessing a small standpipe, has in recent years been operated as a direct pressure system, and will so continue, although there is a considerable demand for an elevated reservoir on one of the nearby hills known as "Gorley Hill," and it is possible that such a reservoir may be built at a later date.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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# PAPERS AND DISCUSSIONS



## DETERMINING THE WEIGHT OF STONE IN VESSELS.

By A. S. Ackerman,* Member Boston Society of Civil Engineers.

This paper considers several methods of determining the weight of cargoes of stone, with special reference to a comparison of the two methods last given.

The first method is the direct one of passing the cargo over scales, usually in flat cars from the quarry, when the net weights of the loads are taken. The carloads are then placed on board the vessel as soon as weighed until a complete cargo is obtained, and the sum of all of the carloads gives, of course, the total weight of the stone cargo. Since the stopping of the flat car at the scales for weighing materially increases the time of loading the vessel, the elimination of this step is desirable. Again, apparatus for weighing large quantities of stone in a short time is not installed at most quarries, nor is it necessary, since the production and sale of rubble stone is generally secondary to the principal output of the quarry. Furthermore, at many quarries there are either no scales or only inconvenient or unreliable ones. This method is accurate, and might be used if the weight of cargo were desired only once. If, however, the determination of cargo weights of successive trips is needed, the fact that this method requires a repetition of the whole operation is the strongest argument against its use.

* Civil Engineer, Newport, R. I.

The second method, that of computing the volume and reducing to weight, is very wide of the mark, but has sometimes been used for small quantities. Even the most experienced inspector probably cannot estimate to within 10 per cent. the volume of a cargo as it passes before him. Moreover, this method necessitates the constant attention of one man, and the result is further affected by any error in the assumption of the weight per unit volume of stone, or if the unit volume is actually weighed, by the variation in weight of a unit volume. Likewise, if a rule is put on each block of stone, which adds to the labor, the result would be nearly as inaccurate, and in reducing volume to weight the result would again be further affected by the variation in weight per unit volume of the stone from different quarries, and even from the same quarry. Also, even while honestly intending to be fair, the man who estimated the cargo of a vessel in this way would be biased in his decisions.

The third method is that of "weighing-in." In determining the weight of a cargo of stone in this way, a method is used which is related to that of obtaining the weight by "displacement" (which follows), since the latter is a factor of both. In other words, the two methods are analogous, since they differ only in the procedure of obtaining values for the curves or tables used. In "weighing-in," the stone is passed over the scales and placed on board the vessel, readings of displacement being taken fore and aft for successive loadings. At the beginning and at the end the load intervals for recording drafts are taken smaller than near the middle in order to establish the curve better at points of more sudden change. Intervals of from 20 to 25 tons, evenly distributed in the hold of the vessel, are usually taken at the start, which may be increased to 50, 75 and 100 tons as the loading proceeds, the intervals being again reduced near the completion of the loading, although the curve at the upper end does not change as fast as at the lower end. The displacement is usually read on two gages, which are vertical glasses set against broad boards located with reference to some immovable and unchangeable points on posts over the keel of the vessel near the bow and the stern. The glasses, or boards, are calibrated to even tons from the results of notes taken at the "weighing-in," by making a plot of recorded drafts to form a displacement curve from which interpolated values are placed on a gage board drawing for record, after which they are scribed on the gage board itself.

The operation of "weighing-in" a vessel takes some time, in a certain case as much as two weeks, as the quarry owners usually are unwilling to make the operation of primary importance to them, and it can be seen that it is a comparatively costly method, including, as it does, the salary and expenses of an inspector and the cost of weighing stone and establishing gages in the vessel. Nevertheless, where the amount of work to be done warrants it, the method is preferable, as it is somewhat easier to read the gages. It is sometimes desirable to make use of a midlength gage to take care of the "hog" in vessels of larger size.

In the fourth or "displacement" method, a displacement volume of the vessel is obtained well outside the maximum and minimum limits, which reduced to weight gives a mass curve from which loads can be directly taken. The procedure is as follows:

The draft marks of a vessel are taken at the stem and stern loaded and again when lightened and pumped out. In the latter condition the vessel is measured, an operation which occupies about an hour after men have become accustomed to taking measurements. The length is taken horizontally on deck, forward of the after part of the stern post, which is called station zero, to a point just forward of the loaded mark on the cutwater, the length being divided into stations of ten feet, and at the bow, sometimes, of five feet. At these stations the semi-widths are obtained to the outer edge of the rail, and then at each succeeding station offsets from a plumb line, hung from the rail by means of an outrigged stick so that the line just touches the side of the hull at the widest part of the section, are taken to the side of the hull at each even foot above light water line, the plumb line being tagged every foot. These measurements are taken as carefully as possible horizontally and normal to the axis of the vessel; and the distance subtracted from the semi-width at the rail plus the distance to the plumb line from the outer edge of the rail gives the semi-width of the vessel at each even foot plane above light water line for each station. After measurements are taken at all stations, the slant of the cutwater and sternpost is obtained in the same manner. Each station section taken as above is plotted on cross-section paper and a curve faired through all the points, which is taken as the mold of the hull at that station for the distance displaced. From these sections distances are taken and a horizontal section of the hull plotted for each foot above light water line. These areas are then planimetered and the volume for each foot computed and plotted as a curve. In determining the cargo carried by a vessel, the mean of the bow and stern displacements is read off the curve, giving the tons directly. In computing the weight, that of sea water is assumed as 64.2 lbs. per cu. ft., and tons are obtained in units of 2 000 lbs.

The two latter methods of weighing stone were used in connection with the building of the Cape Cod Canal breakwater. The method by "weighing-in" was used after a considerable amount of stone had been placed, as during the first season none of the vessels had been weighed in. At this period stone was supplied in sailing vessels, and no way of determining the weight of the cargoes had been provided. The method of determining it by "displacement" was, therefore, suggested by Mr. Eugene Klapp, deputy chief engineer, and developed under the writer, who was then division engineer.

After the first season's work the vessels were weighed in and several cargoes were compared by the two methods. The agreement was very close, the difference being in one case about two tons and in others not more than ten tons. This shows that the two methods last mentioned compare favorably for certain vessels and that the two may be considered of equal value, for the readings of the draft marks in either case are subject to the same errors. The cost of measuring a vessel for the "displacement" method is slight, as three men can easily perform the task in about an hour, after attaining skill, and the office work is about the same as for "weighing-in." The accuracy of the "displacement" method of course depends, among other things, upon the value of the weight of a unit volume of water, but this can be determined by direct measurement.

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# PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

## SLIDE RULES FOR REINFORCED CONCRETE DESIGN.

By E. F. Rockwood,* Member Boston Society of Civil Engineers.

The accompanying illustrations show the fronts and backs of two slide rules for use in the design of reinforced concrete beams and slabs, respectively. These rules were originally designed by the writer in 1908, and constant use of them since that time has developed them into their present forms. Full directions for their use are printed on them.

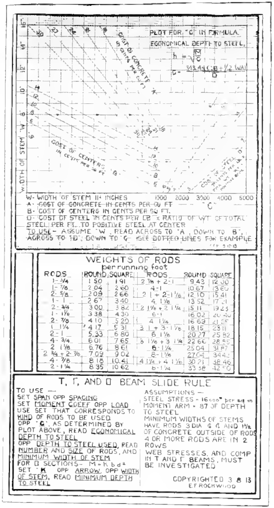
These slide rules have never been put on the market, although the Architectural Department of the Massachusetts Institute of Technology has had a limited number made up for the use of students. In order to assemble one it should be mounted on stiff cardboard, the slides cut out and the remainder of the front pasted on the back in such a way that the slides will occupy the positions shown in the cut. Transparent celluloid should then be fastened to both front and back by means of small rivets or eyelets in order to protect the paper and to form a channel for the slides.

Permission is hereby given to cut out and mount the set printed in this issue of the Journal.

* Chief Engineer, New England Concrete Construction Co., Boston.

PLATE I.
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
MAY, 1916.
ROCKWOOD ON SLIDE RULES FOR REINFORCED CONCRETE DESIGN.

BEAM RULE.



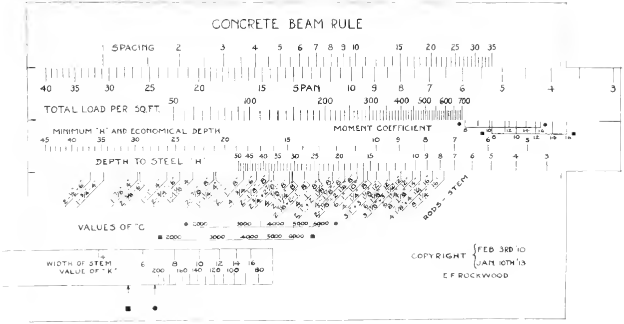
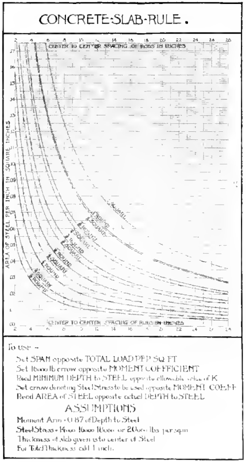
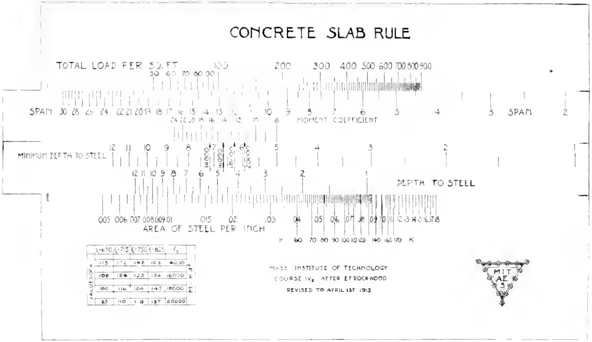



PLATE II.
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
MAY, 1916.
ROCKWOOD ON SLIDE RULES FOR CONCRETE DESIGN.

SLAB RULE.



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**BOSTON SOCIETY OF CIVIL ENGINEERS**
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# PAPERS AND DISCUSSIONS



## DISCUSSION OF "SAND AND OIL ROADS AND SURFACES."

By Messrs. A. B. Fletcher, C. M. Upham, L. W. Page, W. P. Hammersley, John M. Keyes and W. R. Farrington.

Mr. A. B. Fletcher * (*by letter*). — Oiled dirt roads were first built in California in the early nineties. It was, however, between 1900 and 1904 that this type of construction received the greatest attention, and in 1904 some 2 000 miles of county roads and about 500 miles of city streets so built were under traffic.

The percentage of failures of roads of this type is so very high, and the cases where the construction can be regarded as a success are so rare, that, except as a makeshift or in cases where road funds are very low, this construction is but little used in California to-day.

The California Highway Commission has in a few cases made use of oiled dirt roads where heavy fills on new construction required protection from cutting by rain until such time as the fills became sufficiently settled to be satisfactory for concrete or other type of pavement.

Unfortunately, the records kept by county and city officials in this state give but little information as to the character of the oil used. In most cases it was a natural crude oil, contain-

* Highway Engineer, California Highway Comm.

ing from 30 to 60 per cent. asphalt and having a gravity of from 12 degrees to 14 degrees Baumé. The specific viscosities of such oils vary from 1 to 10 (Engler test 100 c.c. at 77 degrees fahr.).

Mr. Farrington's paper deals chiefly with oiled sand roads, and in this particular the work differs from the great bulk of the crude oil roads of California, which generally were built of dirt combined with oil.

The California asphaltic oils, both crude and the heavier manufactured road oils, all show a marked hardening on exposure to weather. The oiled dirt or sand under traffic is generally forced into an uneven surface, partly due to the lack of support of the underlying base in the weak spots of the road and partly due to the fact that a very slight excess of oil in the surface makes a composition which tends to flow to lower elevations. The shoulders of oiled roads in time have a thicker and thicker mat of rather spongy surfacing, too hard to iron out by rolling and too irregular to make pleasant riding.

This construction and the results obtained in California are here discussed somewhat in detail in order that by comparison with the roads described by Mr. Farrington some explanation may be found for their success in Massachusetts.

The "layer roads" described by Mr. Farrington first of all have a hard, properly shaped sub-grade. Clay is added to sandy parts of the road to make the sub-grade a real support for the surface. The oil is applied hot and in two or three applications. The mineral aggregate after each application is spread over the surface of the oil and, due to the higher specific gravity of the sand and by rolling the sand into the oil, it is forced to take up a much higher percentage of aggregate than is found possible under the method used in California.

The oiled dirt roads of California usually after a year or more of weathering will show from 8 to 10 per cent. of bitumen. Mr. Farrington states that $1\frac{1}{3}$ gals. used in the layer treatment gives a thickness of about $3\frac{1}{2}$ ins. This would be only about 4.2 per cent. of bitumen. The oiled sand roads of California show from 7 to 10 per cent. of bitumen. With as low as 4 or 5 per cent. of bitumen the oiled surface should have no tendency to flow or move due to gravity, and where forced out of shape by traffic the oiled surface should be more easily repaired by breaking it up by a scraper and rolling it again to a true surface. This is not the case where the oiled surface contains 8 or 10 per cent. of bitumen. A tough, leathery mass is then formed, which is almost impossible to break up with a scraper.

The actual hardening of the California asphaltic oil, while a benefit in some types of surfacing, is an added handicap when the oiled dirt road once loses its even surface.

Mr. Farrington describes the construction of "mixed sand and oil surfaces." In this construction various grades of oils and asphalts were used. The product somewhat resembles a standard sheet asphalt in which the sand is rather coarser than would be desirable for such a pavement. The coarser sand and the lack of dust would account in part for the construction with as low as 4.5 per cent. of asphalt. This must be a very "dry" bituminous surface, and under any heavy traffic there must be a tendency to crush and break up.

Mr. Farrington says that the best results were obtained by using about 18 gals. of asphalt per cubic yard of compacted sand. This would give between 4.5 and 5 per cent. of asphalt. This asphalt content seems very low.

In determining the proper amount of asphalt to be added to a Topeka surfacing, it is usual to allow asphalt to the amount of about 4 per cent. of the weight of the coarse rock to cover the rock surfaces. That is, if 25 per cent. of rock (passing No. 2 sieve and retained on No. 10 sieve) were used, then $4\% \times .25 = 1.0\%$ of asphalt must be added for the rock. The fine sand and dust will make up about 66 per cent. of the surfacing and will require asphalt to the extent of about 12 per cent. of the weight of the sand. That is, $12\% \times .66 = 7.92\%$. The final mixture would be —

| | |
|---|---|
| Sand, | 66% |
| Rock, | 25% |
| Asphalt 1%+7.9%, | 9% |
| | 100% |

It should be emphasized that 4 per cent. of asphalt is regarded as only enough to coat the coarse aggregate, and where the sand is as fine as is required for a standard sheet asphalt pavement, as high as 12 or 13 per cent. is regarded as necessary.

Certainly the present-day practice in Topeka or sheet asphalt construction does not indicate that a mixture containing only 4.5 to 5 per cent. of asphalt would be "live" or capable of resisting any but very light traffic where the sand is as fine as even the coarsest sand used in the Massachusetts work.

Reverting again to the California oiled dirt roads, it should be explained that sand such as is so common on Cape Cod in Massachusetts is rarely found in California. To transport suitable sand by rail for use with oil would cost more than the result would warrant.

The California "oiled dirt" roads were so named accurately. All materials from adobe to fine sand were treated with oil during the craze.

As already stated, this type of road surface has been abandoned to all intents and purposes, and recently, Tulare County, the home of one of the most skillful of the "oiled road" exponents, has declared that it has "outgrown oiled roads" and needs a better type of pavement.

Mr. Charles M. Upham * (*by letter*). — After reading Mr. Farrington's very complete paper on "Sand and Oil Roads and Surfaces" it appears there is little that can be said in the way of discussion. A few remarks along this line describing experiments performed in Delaware which differed slightly from the Cape Cod construction may be of interest.

As a rule, our sand is much finer, many times all of it passing a No. 10 sieve. It also contains a very large amount of 200-mesh material; sometimes as high as 15 and 20 per cent. Several "layer method" experiments were attempted but none proved successful, the reason being that when an asphaltic oil that would mix with the extremely fine sand was used, it was such a light oil that it had no binding power. Five months after the experiments were tried it would be difficult to find any traces of them. This method was abandoned as a failure.

Several pieces of mixed sand and oil surfaces were laid and, with but one exception, with perfect results. The materials

* Chief Engineer, Coleman Du Pont Road, Georgetown, Del.

were mixed by hand, the sand being heated on pipe heaters. The sand was very fine, about 55 per cent. passing the 50 sieve and 22 per cent. passing the 100 sieve.

Heavier binders were used in the Du Pont Road experiments, the lightest being of 70 degrees penetration (Dow). The low penetration binder and the fine sand made it difficult to mix, but no surface was laid until every particle of sand was coated with binder.

Tests show there was used 5.9 per cent. of binder by weight. The binder used was a petroleum residuum, slightly blown. The consistency of the binder made a pavement that did not soften in the hot weather any more than does a city asphalt pavement. Horse traffic did not "pick up" or "pit" the surface, as is the case when a lighter binder is used, nor has it shown any signs of being brittle in cold weather. One piece has been down nearly four years, and apparently is good for many years more without maintenance. There is medium heavy traffic on this piece of road.

The success of sand asphalt surfaces in this locality can be attributed to the natural grading of the sand and the consistency of the binder that was used, together with the perfect construction, which means having the sand hot and dry, the binder of the proper temperature and the mixing complete.

In no instance has there been used in the Delaware sand oil or sand asphalt experiments any binder with a consistency about 70 at 25 degrees cent. (Dow). The theory was advanced that the low penetration binder would become brittle in the colder weather. Zero weather has not accomplished this, and the experiments have passed through four winters.

In one of the experiments 65 degrees penetration binder was used with a coarse sand. During the first spring a hole developed in the surface. This is attributed to the absence of fine material in the very coarse sand that was used and not to the low penetration binder, as some of this binder was used on an experiment in the same locality where fine sand was used, and it is now in excellent shape and has the appearance of an asphalt pavement.

The thickness of the surface varies from 3 ins. on good foundation to $4\frac{1}{2}$ ins. on the poorer foundations. A seal coat was used in each instance. Cement was tried as a filler, but this proved very costly and it was found by laboratory experiment that any fine material would serve practically the same purpose. Laboratory experiments showed the finer sands as a class to give the most strength.

In summation, the Du Pont Road experiments differed from the Cape Cod construction to the extent of using a finer sand and a heavier binder. By using the heavier binder, horse-drawn traffic has had no more effect on the surface than it would have on an asphalt pavement, and the surface is not dependent on the auto traffic to keep it smooth, as is the condition when lighter binders are used.

The best results in the Du Pont Road experiments were obtained using 65 degrees penetration petroleum residuum.

Laboratory results showed the strength of the sand asphalt pavement to depend greatly on the presence of fine material in the aggregate, and within certain limits they showed that as the fine material increased the strength was increased proportionally. The granulometric analysis of a sand that gave excellent results is given below.

AVERAGE GRANULOMETRIC ANALYSIS.

| | |
|---|---|
| Amount passing 200 sieve | 6 |
| " " 100 " | 15 |
| " " 80 " | 27 |
| " " 50 " | 55 |
| " " 40 " | 70 |
| " " 30 " | 84 |
| " " 20 " | 91 |
| " " 10 " | 98 |

MR. LOGAN WALLER PAGE * (*by letter*). — In Mr. Farrington's most interesting paper on sand-oil construction, a suggestion is made relative to improving this type of road for heavier loads and horse-drawn traffic, by mixing the sand with filler and a bituminous material of lower penetration. In this connection it may be of interest to cite a few facts regarding a

* Director, Office of Public Roads and Rural Engineering, U. S. Dept. of Agriculture.

recent experiment carried out by the Office of Public Roads and Rural Engineering at Ocala, Fla. The sand throughout the section in which this experimental road is located is fine but very well graded, being, in fact, about what is required in sheet asphalt work, as shown by the following analysis:

SAND USED AT OCALA, FLA.

| | |
|---|---|
| Passing 10-mesh sieve, retained on 20-mesh sieve | 1.2% |
| " 20 " " " " 30 " " | 4.0% |
| " 30 " " " " 40 " " | 7.4% |
| " 40 " " " " 50 " " | 11.7% |
| " 50 " " " " 80 " " | 31.8% |
| " 80 " " " " 100 " " | 14.8% |
| " 100 " " " " 200 " " | 20.9% |
| Passing 200 " " | 8.2% |
| | 100.0% |

After light rough grading, the subgrade was shaped with hand tools and hand rolled at a cost of 2c. per sq. yd. A hot sand and asphalt mix, carrying from 9 to 10 per cent. of an oil asphalt, having a penetration of 50 at 25 degrees cent. under a load of 100 grams applied for five seconds, was prepared in a Blystone concrete mixer. Part of the section was laid in two layers, the lower one having a thickness of 2 ins. compacted, and the upper one of 1½ ins. compacted. The remainder of the section was constructed in a single layer having a compacted thickness of 3½ ins.

No particular difficulty was experienced in either method of construction, although the single-layer method seemed preferable on account of the fact that it was easier to secure a true surface, and all danger of parting between the two layers was eliminated. On the other hand, it is doubtful whether maximum compression was secured throughout the entire thickness of the course. In this work it was found possible to handle the hot material from dumping boards along the sides of the road. Where this cannot be done it will of course require special attention to maintain a uniform subgrade and to reshape it after teams have passed over it; also, where practicable, to harden it by the addition of clay or loam, as recommended by Mr.

Farrington. On large contracts it is possible that arrangements could be made for handling the material by means of a dinky engine outfit operating along the shoulders. The road above mentioned was constructed in June, 1915, and has to date given satisfactory service under both motor and horse-drawn traffic, of which the latter includes considerable logging.

The necessity for a seal coat on sand-oil construction is not clearly evident, since it is never employed in sheet asphalt work. Should Mr. Farrington carry out his suggestions of using a harder bituminous material and increase the amount of this material so that it will be from 9 to 12 per cent. by weight of the finished mixture, it is believed that a seal coat will be found to be unnecessary, as in the experiment at Ocala.

Referring to Mr. Farrington's discussion of bituminous gravel construction, an analysis is given below which is fairly representative of about 7 000 lin. ft. of this type of construction which was laid by the Office of Public Roads and Rural Engineering during the summer of 1915.

BITUMINOUS AGGREGATE, USED ON MT. VERNON AVENUE EXPERIMENTAL ROAD, VIRGINIA.

| | | | | |
|---|---|---|---|---|
| Passing | 1-inch screen, | retained on | ¾-inch screen | 6.7% |
| ,, | ¾ ,, ,, | ,, ,, | ½ ,, ,, | 11.4% |
| ,, | ½ ,, ,, | ,, ,, | ¼ ,, ,, | 19.9% |
| ,, | ¼ ,, ,, | ,, ,, | 10-mesh sieve | 12.2% |
| ,, | 10-mesh sieve, | ,, ,, | 20 ,, ,, | 6.5% |
| ,, | 20 ,, ,, | ,, ,, | 30 ,, ,, | 10.5% |
| ,, | 30 ,, ,, | ,, ,, | 40 ,, ,, | 11.4% |
| ,, | 40 ,, ,, | ,, ,, | 50 ,, ,, | 8.9% |
| ,, | 50 ,, ,, | ,, ,, | 80 ,, ,, | 6.1% |
| ,, | 80 ,, ,, | ,, ,, | 100 ,, ,, | 0.8% |
| ,, | 100 ,, ,, | ,, ,, | 200 ,, ,, | 2.8% |
| | | Passing | 200 ,, ,, | 2.8% |
| | | | | 100.0% |

The gravel in this case was a natural bank gravel which seemed to be peculiarly adapted to work of this character. The mixture was prepared in a well-designed portable paving plant and laid to a finished depth of 2 ins. over a well-compacted foundation of the same gravel about 6 ins. in thickness. While this mixture rolled to a fairly dense surface, it was considered advisable to apply a seal coat, of approximately $\frac{1}{2}$ gal. per sq. yd., of bituminous material with a covering of pea gravel. In fact, it is believed that unless the gravel is so graded as to give an exceptionally dense mixture, a seal coat will always prove desirable in construction of this character.

Mr. W. P. Hammersley.* — Before taking up the discussion of Mr. Farrington's paper, it may interest you to know something of the difficulties we experienced in building the first sand-oil roads in Massachusetts. In the spring of 1906 I was sent down to Eastham on Cape Cod by Mr. Farrington, to finish the sand-oil work which had been started the preceding fall. On my arrival I found about half a mile of black, sticky material through which teams had tried to pass (when they couldn't go elsewhere) and which had been badly rutted, while here and there would be a mound or depression where the wheels of passing vehicles had accumulated all they could carry and then dropped it in a pile, the depressions representing the places where it had been picked up by sticking to the wheels, and the mounds where they had dropped their loads. There were also numerous chickens, birds, rats and a muskrat which had been trapped in trying to cross the road.

The instructions I received were rather vague as I remember them, but I understood that the mixture was to be cut up with harrows, raked into shape and rolled. Now that seemed easy, but I assure you that before the job was finished I was about ready to throw up my hands and quit. In the first place, it was mighty hard to get a harrow through the mixture; and in the second place the oil would stick to the disks and finally clog them, or it would stick to the horses' feet until the poor animals were mired. However, after due time and perseverance, we succeeded in mixing enough sand with the oil so that we could, by the aid of plenty of horses and a road scraper, get the road into shape to allow rolling with a horse roller. Then came the task of applying oil on the section not previously covered.

As Mr. Farrington states, the oil was received in tank cars

* Superintendent of Streets, New Bedford, Mass.

supplied with steam coils, to which we attached a boiler, and heated to the necessary temperature so that it could be handled (usually about 200 degrees fahr.). It was then pumped into the most primitive oil distributor you can imagine, — an old upright wooden watering cart supplied with a 4-in. distributing pipe about 7 ft. long, in which two rows of holes had been drilled. Sleeves with corresponding holes, and supplied with handles for adjusting the flow, enveloped this pipe. The shut-off consisted of a weighted wooden clapper over the inlet to this pipe on the inside of the tank, and was operated by a man riding on the top of the cart pulling on a rod attached to the clapper. This did not always work, and usually refused to close when the team became mired, resulting in a surplus of oil being applied at that particular place; also the hot oil caused the wooden tank to shrink so that about as much oil leaked out as was let out through the distributor pipe, necessitating calking the tank very often. Four, six and even eight horses have been required to pull that unmentionable oil cart through some of the soft places. We finally succeeded in putting the oil on the road and working it over with harrows and rakes until we got it into shape so that teams could travel over it without getting stuck.

I might add that people living in Eastham were obliged to change their shoes before entering their homes, and the men working on the road, including myself, were obliged to change our clothes in the barn before we were permitted to go into the house.

I recall a visit of some state officials to the job, one day, when one of the party remarked, "Hammersley, you have my sympathy in trying to make a road out of that stuff"; and if I am not mistaken, our own commissioners had practically made up their minds to cover it up with broken stone or other material. However, it is still there and is really a very fair road. Strange as it may seem, a year or so later, after we had forgotten our previous troubles, it was decided to make another attempt on the road between Orleans and Chatham, and here we had many of the same troubles again until we began to harden the sub-grade and apply the oil and sand in alternate layers.

Without wasting any more time in reminiscences, I will take up the discussion of the very fine paper which Mr. Farrington has presented and from which he hasn't omitted anything essential.

## Sand-Oil Layer Roads.

As stated by the author, the first method pursued was simply to shape up the road as it was found, apply the oil and work sand into it by harrowing, raking and rolling. Later the layer method was used, where the road bed was slightly hardened and the oil and sand applied in alternate layers. He stated that either two applications of $\frac{3}{4}$ gal. each or three applications of $\frac{2}{3}$ gal. each were made. From my experience I am convinced that the latter method is preferable, as it is almost impossible to get thickness enough with two applications to hold up, until the next application is made, even the light traffic of the lower Cape roads. Sufficient time should elapse between the applications to allow the oil to take up as much sand as possible and to allow the lighter oils to evaporate; and as fast as any surplus oil appears on the surface it should be covered, before it is picked up by the wheels of passing vehicles. As to taking care of the weak places which develop, I believe if more attention is paid to the proper construction of the foundation for the oil and sand, the number of these places will be greatly reduced.

My experience has been that ruts and holes usually appear where the roadbed was soft or where cuts had been made in the preliminary grading. These places should be well hardened and thoroughly compacted by rolling before applying the oil. For material for hardening the foundation, I found that sandy loam was generally better than clay, as the tendency with the latter is to apply too much or not thoroughly mix it with the right proportion of sand, so that it would heave and soften up from frost action the following spring, causing the road to rut badly and finally cut through under traffic.

This has been the case, I think, with nearly every road where any amount of clay was used. A layer of sand about $\frac{1}{2}$ in. in thickness should be spread on this foundation before applying the oil. Mr. Farrington states that the best results are obtained by the use of an oil having a viscosity of 500 to 600. It is possible that a slightly heavier oil would give additional stability, but it would have to be applied under favorable conditions in order to incorporate the proper amount of sand. That the shape and grading of the sand has much to do with the success of this or any other type of asphalt surface is without question, as roads where beach sand was used generally rutted badly, until more or less sharp sand was added. This was probably due to the lack of grading, to the round particles making up the beach sand, or to both, but I am certain that the surface was greatly improved by the addition of sharp sand. I have in mind a section of road that rutted badly until some very fine sand was added, after which it became quite smooth, indicating that attention should be paid to the quality and grading of the sand used.

As to the best type of distributor to use, I should say that a pressure machine hauled by a steam roller would give most satisfactory results, or a small truck would be excellent if the sub-grade has been thoroughly hardened and rolled.

## Mixed Sand and Oil Work.

While apparently fair results have been obtained by the use of the hot mixer for combining the sand and oil, I am of the opinion that enough better results would be obtained to amply justify the extra cost of a small portable asphalt plant. This type of plant has been greatly improved during the past year, is economical to operate and easy to control. They are supplied with wide wheels and can be hauled over ordinary roads by auto truck or steam roller. There are many advantages to be gained by the use of a plant designed especially for mixing asphalt pavements, over the hot mixer, which is nothing more than an ordinary concrete mixer supplied with a fire blast.

It is generally conceded by those experienced in making asphalt pavements that a satisfactory mixture cannot be secured with a plant in which the flame comes in direct contact with both the asphalt and the aggregates, the principal objection being that the flame carries with it an excess of oil, which tends to grease the surfaces of the particles of sand and stone so that the asphalt fails to adhere to them, destroying the adhesive qualities of the mixture. In a properly constructed asphalt plant, the flame is applied on the outside of the drum, is carried the length of the drum, usually 10 or 12 ft., and then drawn back through the center of the drum to the stack; in this way any surplus oil is consumed before coming in contact with the aggregates. Another objection, and probably one of greater importance, is that the asphalt, after being heated in kettles and delivered into the mixing drum into which the flame is blown, is in danger of being burned, or heated to such a temperature that the cohesive qualities are again injured and the lighter oils are at once consumed, making a mixture which can only be handled under favorable temperature conditions. Moreover, the sand cannot be heated uniformly where pipes or arch heaters are used for this purpose.

The detrimental effects of this mixing may not show up at once in the finished pavement or even in a year after the road has been opened to traffic, especially if a seal coat, which serves as a protection against the destructive effects of traffic, has been applied. Personally, I think this seal coat is the only thing that prevents surfaces mixed in a hot mixer from going to pieces in a year or two. This can be overcome by the use of a plant where the asphalt and aggregates are heated separately and are mixed in the pug-mill type of mixer and where each operation in obtaining an even temperature and uniform mixture can be easily controlled. This, I can assure you, is anything but easy with a hot mixer, and results in a finished pavement which is neither homogeneous nor of uniform density. A saving of about 10c. per cu. yd. can be made in the cost of heating the sand by using an asphalt plant as described instead of arch or pipe heaters, comparative costs being approximately 25c. and 35c. per cu. yd.

In regard to the quantity of oil used, Mr. Farrington states that best results have been obtained with about 16 gals. per cu. yd. of loose sand, an amount which gives approximately 4.8 per cent. in the finished pavement. From records of successful asphaltic concrete pavements which have been in use for a number of years, it would seem that the mixture should contain from 8 to 10 per cent., depending of course on the grading of the aggregates, the finer material requiring more asphalt than coarse aggregates.

More or less trouble has been experienced by "balling" of the asphalt, which was attributed to the sand not being thoroughly dried or to lack of oil, but probably the real cause was lack of 80- and 100-mesh sand in the mixture.

In regard to rolling, I do not favor the use of a horse roller as it is almost impossible to get the indentations caused by the tamping effect of the horses' feet out of the surface. I believe that the best results can be obtained by the use of a small tandem roller, weighing about three tons, followed up with a 10-ton roller. The rolling should be begun while the mixture is still hot, else the maximum density will not be secured. This would also allow the mixture to be scraped to an even surface before it has had a chance to become hard, and would result in getting a smoother road.

The trouble caused by shoving and moving of the mixture during the preliminary rolling can be overcome to a certain extent by preparing a hard, smooth and unyielding subgrade. Cross rolling will also aid in removing some of the irregularities in the surface.

In regard to the consistency of the asphalt used for the sand and oil mixture, I would choose an asphalt somewhat heavier than that mentioned by Mr. Farrington as giving the best results, and I think this is borne out by the statement he makes when he says that "if the grains of sand are rounded, and especially if the sizes vary but little, etc., a very heavy asphalt gives the best results." It seems to me the same thing holds true with any sand, and I think that a more stable mixture will result from the use of an asphalt of from 60 to 70 penetration. As for the aggregates, it seems to me that a mixture of approximately 25 per cent. of sand and gravel which will pass a $\frac{3}{4}$-in. and be retained on the $\frac{1}{4}$-in. screen with 65 per cent. of the sand graded as for sheet asphalt and 8 to 10 per cent. of asphalt would be satisfactory for such roads where this type of surfacing would be used. While it is usually difficult to find sand containing enough of the finer particles, a small amount of stone dust or what is commonly called No. 3 stone can be added at a small additional cost, or even the use of Portland cement would be warranted by the improved quality of the mixture.

Mr. Farrington states that a fairly coarse, sharp, well-graded sand gives the best results. This probably is true where the traffic is light, but at the same time there should be enough of the fine sand to reduce the percentage of voids to a minimum in order to get density and stability.

In hardening the subgrade, the nearer we approach the stability of concrete, the more satisfactory will be the results, and I believe the day is not far distant when concrete will be extensively used for the base of nearly all road surfaces where there is any considerable amount of traffic. As to a seal coat being applied to the surface, it does not seem to be necessary when the aggregates are properly graded and combined with good asphalt, and the mixture rolled to its maximum density, or at least not more than a squeegee coat should be needed simply to seal the surface and not to act as a wearing course.

## Traffic.

Mr. Farrington has covered the subject of traffic pretty thoroughly, and I fully agree with him as regards the success of mixed sand and asphalt surfaces for medium traffic when scientifically combined and properly laid.

## Specifications.

The specifications submitted fulfill the requirements pretty thoroughly, but there are a few points which I would like to discuss. It is doubtful if 3 ins. of hardening will be sufficient in all cases, and I should make this requirement more elastic, to meet such conditions as may be encountered. I would also provide for ½ in. of coarse sand being spread on the subgrade, on which the oil shall be applied, and instead of making it a requisite that a definite amount of sand should be spread on each application of oil, I would specify that sand should be applied in thin layers until no surplus of oil appeared on the surface after rolling. We have found that more sand could be worked into the oil in this manner than when a lot of sand was spread at once.

I would also recommend a lower maximum temperature to which the oil should be heated, say not over 325 degrees fahr., especially if a hot mixer is used, and I would increase the amount of oil used so that the finished pavement would contain from 8 to 10 per cent., depending on the grading of the aggregates.

Mr. John S. Keyes * (*by letter*). — I don't know as I have any criticism to make of Mr. Farrington's paper except in the matter of rolling. I do not think it is necessary to use a tandem roller, as satisfactory results have been obtained under my supervision by using an iron hand-roller filled with water weighing about 500 lbs., rolling first lengthwise with the road, care being taken to commence rolling at the gutters so as to preserve the crown of the road, and finally a light horizontal rolling to iron out the surface. We haven't any tandem roller in Concord, so we were obliged to use this method. The sand and gravel are heated and mixed by hand in the pit and delivered on the job at once. The oil used was Standard Oil Binder " B " and Texas Asphalt No. 96 heated to about 300° fahr. The gravel used was clean and sharp, free from loam and clay, not over 15 per cent. being retained on a half-inch mesh and nothing passing a 200 mesh, and was mixed with about twenty gallons of oil to the cubic yard. I do not believe a horse roller is satisfactory on the oil and gravel surface, as the horses' feet pick up more or less material and tend to make depressions which to my mind are difficult to eradicate; however, in my experience a scraper has never been used as described by Mr. Farrington. Our method here is to roll the subgrade very thoroughly and smoothly. I disagree with Mr. Farrington where he says, " In constructing a mixed sand and oil surface, the subgrade is shaped and, if sandy, is hardened with the best material available, usually sandy loam or clay." I should never, if possible to avoid it, use any loam or clay in the subgrade; trouble would be sure to arise under the frost action, and I should expect to find the road breaking up under these conditions. We use cobblestones from the gravel pits for all our

* Chairman, Department of Roads and Bridges, Concord, Mass.

subgrade, filling the voids, after rolling, with coarse gravel, and then rolling to a true grade; over this we spread, while hot, the mixture as described above to a depth of $2\frac{1}{2}$ ins. and roll with hand roller, keeping the traffic off for twenty-four hours. The crown should never be over $\frac{3}{8}$ in. to the foot; in fact, $\frac{1}{4}$ in. to the foot seems preferable; this surface being watertight, small pitch is necessary to shed the water to the gutter. No seal coat is applied till the second year. The cost is thirty-seven cents a square yard above the subgrade.

We have a section of our Main Street which was built in this manner five years ago, with these exceptions; the depth was 4 ins. and the cost, fifty-four cents a square yard. This has never required any repair, and carries a mixed traffic of market wagons and automobiles. The maximum automobile traffic is 1 125 an hour on pleasant Sundays and holidays during the summer season. Regarding layer roads, it would be hard to improve Mr. Farrington's method.

Mr. W. R. Farrington* (*by letter*). The writer notes, in the discussion on sand and oil roads, that considerable stress is laid on the apparent deficiency of bituminous material in the mixture used on state highway work in Massachusetts, it being stated, by some of those taking part in the discussion, that probably much better results would be obtained by the use of about twice the amount. In this connection the writer would call attention to three points.

*First.* The percentage of bituminous material used on the state highway work was determined only after two or three years of actual experience. It was found that a less amount would not thoroughly coat the grains, and that an additional amount not only was apparently unnecessary but that it was actually detrimental in that surfaces constructed of such mixtures would not hold their shape and tended to rut and crawl under travel. It seems to be a well-established fact that on asphalt or oil-asphalt work, the best results are obtained by the use of just the amount of bituminous material required to thoroughly coat the grains of sand or larger aggregate, and that the finer and better graded the aggregate, the more bituminous

* Author's closure.

material is required. Tests made of sand used on the state highway work show that the sand or sandy gravel used is deficient in fine grains, according to the sheet asphalt or Topeka specifications. In the opinion of the writer, this explains the fact that additional bituminous material does not give better results. There is no doubt that better graded sand would give better results, as is evidenced by results from the use of cement as mentioned, but the addition of cement or other materials to improve the grading means additional cost.

*Second.* The sand and oil mixture serves not only as a wearing surface, but also takes the place of the base or foundation, any hardening used on the subgrade being sufficient only to carry the travel during construction, and not adding any material strength to the surface. It is possible that under such conditions a somewhat different mixture is called for than where the mixture serves only as a wearing surface on a good gravel, broken stone or concrete base.

*Third.* In the sections where the sand and oil roads have been constructed, the conditions do not warrant an expensive surface. With the materials available, to approximate either a sheet asphalt or a Topeka specification mixture means a large cost. Doubling the bituminous material used would alone add from 15 to 20c. per sq. yd. to the cost. However, as stated, if it is found practicable to grade the material for the wearing surface only, it would seem possible to use sand and oil with good results, in other sections where the travel is heavier, and the conditions would warrant the additional cost.

In the opinion of the writer, the reason for the successful results obtained with the sand as found in the ordinary pit and the amount of bituminous material used, is the seal coat, which apparently has been overlooked by some of those taking part in the discussion. As stated, the first mixed roads were not sealed when constructed, and with these a tendency to disintegrate was observed within a year or two. The application of a seal coat stopped this tendency. The seal coat, without doubt, contains a larger proportion of bituminous material, it prevents moisture working into the mixture and it forms a surface which is somewhat resilient but is not of sufficient thickness to rut or roll under travel. The cost of the seal coat, which adds about $\frac{1}{2}$ in. to the thickness of the surface, is only 6 or 8c. per sq. yd., whereas the addition of 4 or 5 per cent. of bituminous material will increase the cost from 15 to 20c. per sq. yd., and, in the opinion of the writer, additional bituminous material cannot be used advantageously without grading the sand, which means further additional cost.

Relative to Mr. Fletcher's description of the oil and dirt roads in California, the writer would state that the sand and oil layer roads in Massachusetts have acted when constructed much the same, although eventually we have in most cases succeeded, by the addition of sand, etc., in obtaining a mixture which does not rut or roll badly under the travel to which these roads are subjected. It seems well to state also that we have not in any case obtained good results from the use of clayey or loamy soils, although, as stated, the presence of a small proportion of clay or loam is not objectionable, if properly divided and distributed throughout the mass.

Relative to the use of an asphalt plant, bids have in several instances been asked for and received from parties who have had such an equipment, but in all cases the bids have been very high, and all interested have agreed that such a plant could not be used profitably at the prices for which the work is being done with other equipment, as a suitable asphalt plant means not only a large first cost, but a much greater cost for transportation between jobs, than with the equipment now being used.

As to the question of the oil or oil-asphalt being burned, or the grains of sand so coated with light oil from combustion of the crude oil used in the burners that good results cannot be obtained with a mixer so arranged that the flame comes in direct contact with the materials during mixing, the writer, who has had an opportunity to watch most of the state highway sand and oil work in Massachusetts and observe the results on the roads after the surfaces have been subjected to travel for several seasons, fails to see any indication of burning of the bituminous material or sufficient coating of the aggregate to affect the results. This conclusion is also apparently corroborated by the reports of chemists of the Office of Good Roads, and others who have tested not only the fresh mixtures, but also samples of the mixture taken from surfaces more than three years old.

As to the possibility of thoroughly drying the sand with pipe or arch heaters, the writer, as a result of careful observation, believes that it is possible to obtain as good results with these heaters as with a mechanical heater, provided the sand is properly turned on the heater or shoveled from one heater to another as it should be, but realizes the difficulty of obtaining this result with ordinary labor, and it is principally for this reason that the use of a mechanical heater is advocated, since a careful comparison of the costs does not seem to show much advantage in the latter, taking into consideration the first cost, etc.

Relative to rolling, no difficulty has been experienced in rolling with a tandem roller, on a broken stone or other hard base, a layer of sand and oil 2 ins. thick after rolling, but even with such a base the use of a steam roller is impracticable at first with a sufficient amount of the mixture to give about 4 ins. after rolling. On the other hand, when a horse-roller is used, no difficulty is experienced in removing the inequalities caused by the horse's feet, provided a suitable scraper is used during the rolling.

As to cross rolling, while the writer has no doubt that this is advisable with wider surfaces, it does not seem practicable with a 16 or 18 ft. surface, if the shoulders are too soft to carry the roller, as is usually the case where the sand and oil roads have been constructed. In such cases, cross rolling not only tends to force the surface out of shape, because of the short turns it is necessary to make in rolling, but also results in breaking down the edges.

## MEMOIR OF DECEASED MEMBER.

### JOHN HERBERT GERRISH.*

Died February 7, 1916.

JOHN HERBERT GERRISH, son of John J. and Susan (Small) Gerrish, was born in Portland, Me., October 13, 1858. He was the eldest of a family of six, three brothers and three sisters.

Mr. Gerrish was educated in the public schools of Portland, and in his first business experience was associated with his father in furnishing railroad supplies. After a few years he entered the employ of the Eastern Dredging Company, and in 1887 came to Boston as the agent of the company, and upon the death of Mr. Wright, the president, Mr. Gerrish became treasurer, which position he retained until he retired from the company in 1913. During this period he was the active head of the company, which was working on many of the larger public works in and around Boston harbor and at other places along the New England coast, among them the deepening and enlarging of the channels and anchorage basin in Boston and other harbors; the Cape Cod Canal, the Charles River Dam, the building up of the South Boston flats and many other works.

Mr. Gerrish was married in 1883 to Ida L. Thurston, of Portland, Me., and had a family of nine children, eight of whom survive him, three boys and five girls.

Mr. Gerrish and his family moved from Portland to West Medford in 1887 and, after a residence there of eleven years, moved to Melrose Highlands, at 20 Farwell Avenue, in 1898, where the family still resides.

Mr. Gerrish was also treasurer of the Gerrish Dredging Company; treasurer of the Boston Mailing Company; member of the Boston Chamber of Commerce, the Boston City Club,

* Memoir prepared by Frank W. Hodgdon and John L. Howard.

Boston Society of Civil Engineers, Massachusetts Real Estate Exchange, and West Medford Lodge, I. O. O. F.

In his religious life he was a member of the Congregational church and was always actively interested in the church work in the place where he resided.

Mr. Gerrish was a man of unassuming merit, who made many warm friends, and was always ready to give of his time and energy to assist any worthy cause and do his share of the work in all cases.

He was a most domestic man, and devoted to his family and home life.

Mr. Gerrish was elected an Associate of the Boston Society of Civil Engineers on May 18, 1898.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PAPERS AND DISCUSSIONS



## THE YALE BOWL.

By Thomas C. Atwood.*

(Presented May 17, 1916.)

The greatest of amphitheaters for the witnessing of outdoor sports has been erected at New Haven, Conn., for the use of Yale University.

It is designed especially for football contests, but can be used for outdoor pageants and spectacles and for any games which can be played upon the 300 ft. by 500 ft. oval-shaped playing field, but it is not suited to baseball or track games. The principal reasons for this are that, for the large seating capacity required, a field of the right size and shape for baseball would necessitate placing spectators too far away to properly see football, while the design of the structure is such that to accommodate the 220-yd. straightaway for the track games, a tunnel would be necessary, which would give poorer running conditions than a track in the open and which would cost as much to build as an ideal track with suitable grandstand on a nearby location.

The structure has been named "The Yale Bowl" on account of its resemblance to a huge bowl, rather than adopting the name of a similar ancient structure such as stadium or

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, by August 10, 1916, for publication in a subsequent number of the Journal.

* Consulting Engineer, New Haven, Conn.

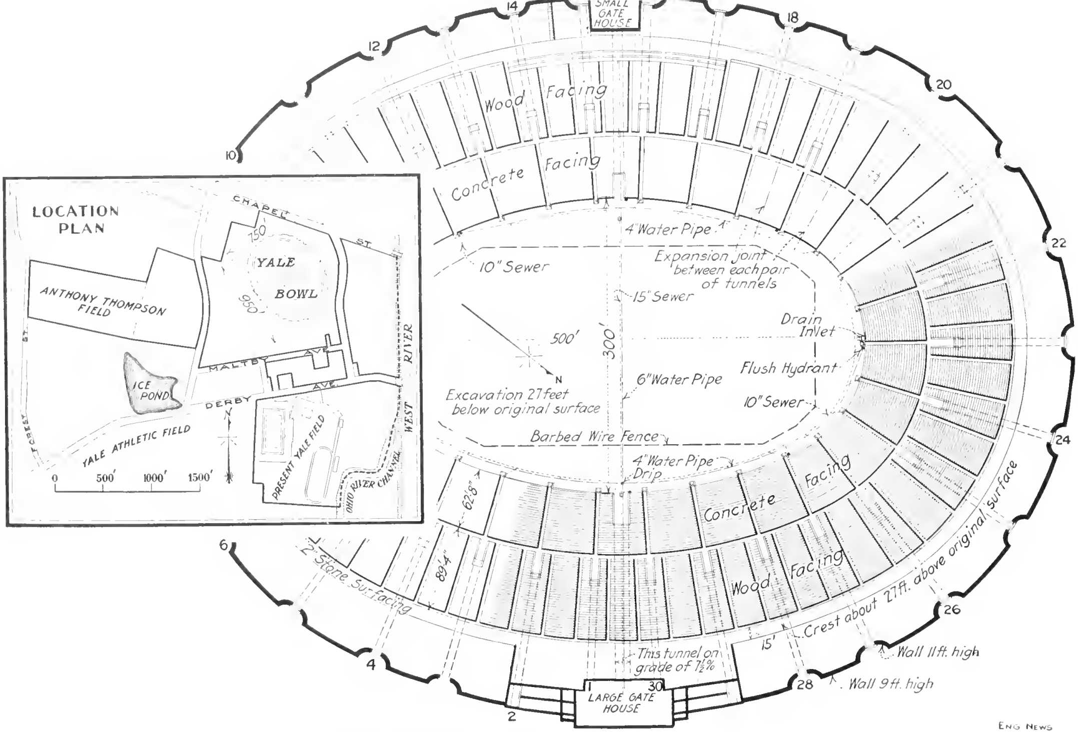
LOCATION PLAN
ANTHONY THOMPSON FIELD
YALE BOWL
750
950
CHAPEL
ST
MALTBY
AVE
DERBY
AVE
ICE POND
YALE ATHLETIC FIELD
PRESENT YALE FIELD
OHIO RIVER CHANNEL
WEST RIVER
FOREST ST
0
500'
1000'
1500'
SMALL GATE HOUSE
LARGE GATE HOUSE
Wood Facing
Concrete Facing
4" Water Pipe
10" Sewer
Expansion joint between each pair of tunnels
15" Sewer
Drain Inlet
Flush Hydrant
500'
300'
6" Water Pipe
10" Sewer
Excavation 27 feet below original surface
Barbed Wire Fence
4" Water Pipe
Drip
62'8"
89'4"
2" Stone Surfacing
This tunnel on grade of 7½%
15'
Crest about 27 ft. above original surface
Wall 11 ft. high
Wall 9 ft. high
Eng News

FIG. 1.

colosseum. The Bowl follows closely the design of the stadium at Pompeii.

Work was started June 23, 1913, President Arthur T. Hadley turning the first sod. The structure was sufficiently complete to allow holding the first game within it on November 21, 1914.

## Location.

The Bowl is located on the western side of New Haven, about $1\frac{1}{2}$ miles from the center of the city and just north of the old Yale Field, on a level piece of ground lying between Chapel Street and Derby Avenue. It is on the west side of West River, and close to the high bank which the river has formed by cutting into the level plain of sand and gravel on which New Haven is largely built. (Fig. 1.*)

The location is an ideal one for this type of structure, the gravel and sand being coarse as a rule, but containing no cobblestones over 4 ins. in diameter. Much of the sand is excellent for concrete in its natural condition, while most of it can be made so by screening out the gravel, although some is too fine. The upper 10 ft., approximately, contains nearly all of the gravel. Below this depth is found sand varying in fineness, but generally free from particles over $\frac{1}{4}$ in. in size. This lower sand is, as a rule, very clean, while the sand in the upper 10 or 12 ft. is quite strongly colored by iron so as to give a pinkish tinge to the concrete made of it.

This location has the advantage of being about midway between two lines of street cars, while the direct road to the center of the city is free from cars at this point and can be used entirely by pedestrians when the big games are played. This operates to reduce very largely the danger of accident. A wide avenue was made on the easterly side of the Bowl, between it and the river bank, giving a dignified approach on this side. The northerly side is bounded by Chapel Street, and the south and west sides by land owned by the committee, which will be developed for athletic purposes.

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* The Society is indebted to *Engineering News* for the cuts used to illustrate this paper.

## Design.

The Bowl differs from most modern amphitheaters in being essentially an earthwork structure. It is built in a level plain by excavating the center of the field and using the excavated material to make an embankment around the outside, this embankment forming a complete oval about the playing field. The seat slabs are placed directly upon the earth, making it a structure which cannot fall down.

The surface of the playing field is about 27 ft. below the original surface of the ground, while the top of the embankment is about 27 ft. above the original surface of the ground, the promenade around the top being 54 ft. above the playing field.

A wall 4 ft. high surrounds the field, thus giving 50 ft. rise in the bank of 60 rows of seats, or an average rise of 10 ins. per row. The actual rise varies increasingly from 8 ins. at the bottom to 12 ins. at the top, thus enabling spectators on all parts of the slope to see the field with equal facility.

Access to the Bowl for spectators is provided by 30 tunnels, each 7 ft. wide by 8 ft. high. These extend from the ground level outside to about midway of the seat bank, and aisles lead up and down the slope from the inner ends of the tunnels.

Access to the playing field from the outside is given by two tunnels, one 15 ft. wide by 10 ft. high and suited for entrance of vehicles, steam roller, etc., and the other 10 ft. wide by 8 ft. high and suited only for pedestrians, as it contains stairs, being the only tunnel so constructed. At the outer ends of these two tunnels, which are on the short axis of the ellipse, will be built two ornamental buildings called Gate Houses, in one of which the home team will be housed, while the visiting team will find quarters in the other. Access may also be had to the playing field by a flight of steps at the foot of each aisle.

After the games a considerable proportion of the spectators usually go down on to the playing field, and the two large tunnels just mentioned provide means of easy exit for these crowds as well as for the entrance and exit of processions and pageants.

The outside dimensions of the main structure are 933 ft.

by 744 ft., and the structure together with its approaches covers an area of 25 acres. The playing field is an approximate ellipse made up of circular arcs, the long axis being 500 ft. and the short axis 300 ft.

The field is so laid out that the main axis, which is also the long way of the football field, lies about northwest and southeast, so that the sun in the autumn afternoons will be at right angles to the long axis and will not shine in the eyes of the players looking toward either goal.

The principal quantities involved are as follows:

| | |
|---|---|
| Excavation | 300 000 cu. yds. |
| Embankment | 175 000 cu. yds. |
| Concrete | 25 000 cu. yds. |
| Concrete facing | 110 000 sq. ft. done |
| Concrete facing | 150 000 sq. ft. yet to be done |
| Steel reinforcement | 500 tons |
| Granolithic pavement | 36 000 sq. ft. |
| Drains, 6-in. to 24-in. | 6 400 lin. ft. |
| Water pipe, 4-in. to 6-in. | 4 700 lin. ft. |
| Waterproofing | 48 000 sq. ft. |
| Pitch mopping | 109 000 sq. ft. |
| Wood seat benches | 20 miles |
| Area macadam walks | 19 000 sq. yds. |
| Turfing | 4 acres |
| Area graded | 40 acres |
| Time of construction | 17 months |

## Excavation.

As stated previously, this stadium is essentially an earthwork structure, and consequently the excavation formed the biggest item. The loam which covered the site was first taken off and placed in separate piles of black loam and yellow loam. The depth of the black loam averaged about 10 ins. and of the yellow loam about 12 ins. Both were of a sandy quality, particularly the yellow loam, some of the latter being but little better than the sandy gravel beneath it.

The gravel was placed in the embankment at first partly by drag and wheel scrapers, but the main dependence for the excavation was placed upon two large drag-line excavators operated from 85-ft. towers which moved on elliptical tracks built closely around the outside of the Bowl. These towers operated buckets weighing about 4 500 lbs. and having a capacity of about 2 cu. yds. The buckets were hauled in toward the tower by a single cable attached to a drum of the engine and run out by gravity on the main cable, which was pulled up taut by block and fall attached to the head of the tower, and held taut until the bucket had run out as far as desired and then slackened. The other end of the main cable was attached to a post which was moved from time to time so that the bucket might dig from the exact spot desired. Theoretically, a post could have been located at the center of any section of the track which was approximately a circular arc, and all of the material within the sector could have been removed by the bucket, but several practical considerations prevented this from being carried out in the main part of the excavation, although towards the end, when the banks were trimmed by dragging special buckets up the interior slope, this came very near to being the actual layout.

The maximum output of one of the excavators was about 1 500 cu. yds. running twenty-two hours, while the largest month's work for the two was about 45 000 cu. yds. Considerable experimenting was necessary before the exact design of bucket was found which would load itself in the bottom of the hole, and would travel up the slope without digging into the bank which had already been built. The proper shape was finally found, and the buckets worked very well with only an occasional accidental digging below grade, which usually took place during the night, when the light and supervision were not particularly good. Quite a little difficulty was experienced in digging through the 10 ft. of sandy gravel, which was fairly compact, although the buckets were heavy and equipped with strong teeth. After this was past, however, the digging was very good and the machines worked easily. Most of the excavation outside of the Bowl as well as a portion of that inside was made by two Thew rotary steam shovels with $\frac{5}{8}$-cu. yd. buckets loading dump wagons.

## Embankment.

The specifications called for the embankment above the tops of the tunnels to be rolled in 6-in. layers, and the method of operation was for the drag buckets to make three piles of material between each pair of tunnels, the piles being tent-shaped and usually about 3 ft. high, 8 ft. wide and as long as the bank width. These piles were figured to contain just enough material to make the 6-in. layer, being the most practical way in which to regulate this depth.

As the towers moved along, they were followed up by teams with leveling boards, which leveled off the piles to a fairly uniform surface, and this was thoroughly wet down by water from lines of hose and rolled eight times, each point being gone over four times by a grooved roller and four times by a smooth roller alternately. The rollers weighed about 800 lbs. per lin. ft. and as a rule required four horses, although occasionally a very heavy team would be found which could operate one for a few days without assistance. One larger roller, which required six horses, was used for a time. Large quantities of water were used. The contract called for 150 gals. per minute, to be run on to the bank night and day.

Below the tops of the tunnels, where rolling was not practicable, the material was watered very heavily, and after the fill had got above the tops of the tunnels, special efforts were made to make sure that the water had penetrated to every portion of the embankment by damming off a section at a time and running all of the water into this section, and punching holes in the bank about 8 ft. on centers by means of drills or water jets. In this way the whole embankment received a uniform treatment, which could not have been assured otherwise, for the sand was so porous that the water from a 2-in. hose would disappear into the bank within 5 or 6 ft. from the end of the hose, and with operation by the ordinary Italian water boy, it was impossible to tell whether every portion of the embankment had been thoroughly soaked or not.

When the embankment had been carried nearly to its full height, the excess material on the interior slope was dragged up to the top of the bank by heavy timber frames operated by the drag scraper towers in the same manner as a bucket, these frames being about 10 ft. square and having heavy iron plates projecting below the front edge, acting much like a leveling board. They could be made to trim just where it was desired by tightening up the main cable so that they could not go below grade at any point, and they did very good work in shaping up the bank. The final trimming was by hand.

The outer slope of the embankment was trimmed partly by leveling boards operated by power and partly by hand, and was then covered with about 10 ins. of loam, into which strips of turf about 8 ft. on centers were embedded, running parallel to the top of the bank, with the idea that they would help to distribute rain water and prevent it from getting together in sufficient volume to do much damage before it struck another line of turf and was spread out again.

The outer slope of the embankment is sloped approximately 1 on 2, except around the portals, where it is about 1 on 1½. These steep places were turfed entirely, but the remainder of the slope was seeded with a mixture of 11½ lbs. of red top, 5 lbs. of Kentucky blue grass and 20 lbs. of white clover. This grew rapidly and seemed to be very good mixture for the purpose, the clover springing up quickly and protecting the grass while it was starting. In this region clover generally dies out after two or three years, while the red top is the native grass and will get a good start by that time.

During the placing of the loam and turf a torrential rainstorm occurred, in which the theory of the strips of turf was thoroughly tested and found to be correct. Small gullies formed between the strips of turf, being at most an inch deep at the upper end and 3 ins. deep at the lower end and close together, almost as if a very coarse rake had been dragged down the slope from one strip to another. In no instance did the water dig underneath the turf, and the gullies at the foot of the bank were very little larger than those up near the top. The total amount of dirt washed away was small, and the only repair necessary was going over with a rake to smooth the slope up once more.

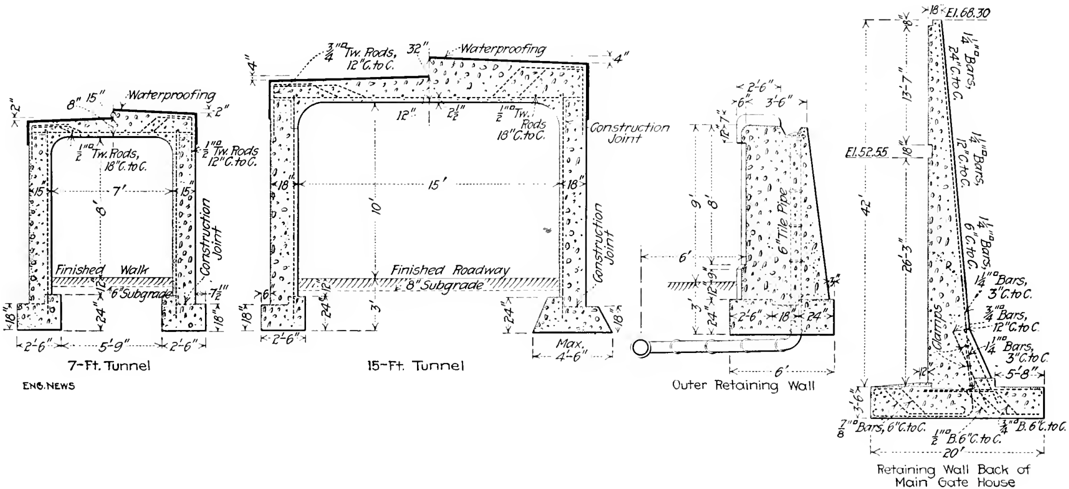

7-Ft. Tunnel
Waterproofing
½" Tw. Rods, 18" C. to C.
½" Tw. Rods 12" C. to C.
Construction Joint
Finished Walk
6" Subgrade
15-Ft. Tunnel
¾" Tw. Rods, 12" C. to C.
Waterproofing
½" Tw. Rods 18" C. to C.
Construction Joint
Finished Roadway
8" Subgrade
Max. 4'-6"
Outer Retaining Wall
6" Tile Pipe
Retaining Wall Back of Main Gate House
El. 68.30
El. 52.55
1¼" Bars, 24" C. to C.
1¼" Bars, 12" C. to C.
1¼" Bars, 6" C. to C.
1¼" Bars, 3" C. to C.
¾" Bars, 12" C. to C.
Clamps
⅞" Bars, 6" C. to C.
½" B. 6" C. to C.
¾" B. 6" C. to C.
ENG. NEWS

FIG. 2.

## Retaining Walls.

The outer slope is held at the bottom by a retaining wall 9 ft. high in the clear, and the inner slope is held at the bottom by a wall 4 ft. high in the clear. These are both heavy gravity type walls and are built in short lengths separated by pilasters, thus providing an ample number of contraction joints. The maximum length of wall without joint is about 23 ft.

The 9-ft. wall on the outside is made extra wide at the top so as to contain a gutter which takes the drainage from the slope above and carries it to drain pipes discharging down through a pipe built into the wall to the drain around the outside of the Bowl. A cross section of this wall is shown. The wall has stood well except in two places, where slight cracks have developed, due apparently to unequal settlement in the foundation. The main outer wall is connected to each of the tunnel entrances by two curved approach walls, approximately of similar design to the main wall. (Fig. 2.)

The interior wall also has a gutter around its top to take the flow from the inner slope, but this gutter instead of being open, as in the previous case, is covered with a cast-iron grating, as it forms part of the foot space under the seats.

The forms for both these walls were removed as soon as practicable, and the exposed surfaces rubbed up with wooden floats so as to remove board marks and leave a rough finish. This finish is on the whole quite satisfactory. The pilasters and coping of the exterior wall were finished with a smooth, hard-troweled surface with considerable neat cement added, and a good deal of crazing occurred, and in a few cases scaling started. An attempt was made to stop this by applying a waterproofing concrete paint, but it is too soon to tell whether this will be successful or not. The paint used was the "Transparent Driwal" of the Billings-Chapin Company, with a slight amount of the "Bluestone Driwal" added to cover the craze cracks and give a uniform color. The faces of the tunnel portals were covered with spatter-dash finish which looks very well, and has stood so far in good shape.

The two gate houses mentioned above set into the embankment in such a way as to require retaining walls behind them of the full height of the bank from the outside ground level to the top. One of these is at the outer end of the Players' Tunnel, where the Smaller Gate House is to be erected, and the other at the end of the Main Tunnel, where the Main Gate House is to be erected. The former is of the gravity type, 34 ft. high, while the latter is of reinforced concrete cantilever type, without counterforts, being one of the highest walls of this type ever built, the maximum section being $45\frac{1}{2}$ ft. high from the bottom of the 3.5-ft. foundation to the top of the earth fill. It was realized that the counterfort type was more economical, but it was not used, as buttresses could not be placed on the front side without interfering with the building, and counterforts placed on the back side would have interfered with the rolling of the embankment. (Fig. 2.)

The wall was built by placing the foundation first as a separate operation and then carrying the vertical part of the wall up in monolithic sections of convenient length, the maximum length being about 47 ft. The maximum height placed in one day was 42 ft., and as this was placed mostly in cold weather, some trouble was had with the forms at first, due to insufficient bracing, but this was soon remedied, and the remainder of the wall was placed without accident.

The reinforcement was very heavy, and some unusual precautions were taken in connection with this. At the deepest section the main reinforcement consisted of $1\frac{1}{4}$-in. square bars placed 3 ins. on centers, which left very little concrete between them. A splice was made in these bars just above the foundation by a five-foot lap, and it was feared it would have a tendency to split off the face of the concrete, due to internal strains being greater than the concrete could stand, so it was decided to place clamps upon the bars, which would have the double effect of preventing them from splitting out the surface of the concrete, and would also tie the bars together so that a large part of the stress would be carried from one bar into the other without going through the concrete at all. Some experiments were made to determire what could be done with these clamps, and results were as follows:

In the first test, a U-bolt of $\frac{3}{4}$-in. steel was used, with heavy cast-iron cross head. The reinforcing bars used were the $1\frac{1}{4}$-in. Havemeyer bars, and the clamp was put over two of these bars and tightened up moderately. The first slip was at 4 000 lbs., and amounted to $\frac{1}{4}$ in. before holding again. The bars were then taken out and put into a vise and the clamp tightened up hard with a 24-in. wrench. This time the first slip was at 5 100 lbs. and the test was continued until it held 19 800 lbs., by which time it had slipped $1\frac{1}{4}$ ins., most of this, however, being after 15 000 lbs.

The next test was on a $\frac{5}{8}$-in. U-bolt with a plain steel strap cross head, the strap being $\frac{1}{2}$ in. thick and $1\frac{1}{2}$ ins. wide. This was tightened up with the 24-in. wrench and the first slip was at 2 700 lbs.

The next test was on the same, the first slip being at 3 200 lbs.

For the next test both clamps were put on and tightened up hard, the first slip occurring at 10 000 lbs.

In the next test the two clamps were used again, and put 16 ins. apart, a $\frac{1}{2}$-in. bar being placed between the reinforcing bars half way between the clamps, with the idea that by bending the reinforcing bars around this small bar a greater resistance to slipping might be obtained. This proved not to be the case, however, as the first slip occurred at 6 200 lbs.

After these tests were completed we attempted to break one of the reinforcing bars, but without success, the capacity of the testing machine being only 100 000 lbs. The maximum load on the bar was 98 000 lbs., the yield point being apparently at about 86 000 lbs. It was decided to use three of the large clamps on each splice, expecting to develop thereby about 15 000 lbs., which is about two thirds the working load on the bars, thus relieving the concrete largely of stress.

The placing of the clamps was carefully watched by the inspector, the nuts being tightened up with a 24-in. wrench. The cross heads used were $\frac{3}{4}$-in. by $1\frac{3}{4}$-in. steel bars, as these were found to be less expensive than the cast-iron and apparently about as effective. The U-bolts were of $\frac{3}{4}$-in. steel with $1\frac{5}{8}$-in. by $3\frac{3}{4}$-in. clear opening, the length of bar being 13 ins. with $2\frac{1}{4}$-in.

thread. The complete clamp weighed nearly $3\frac{1}{2}$ lbs., and cost 25 cents each. The tests were made in the Mason Laboratory of the Sheffield Scientific School, by Dr. W. K. Shepard and the writer.

In addition to this, the concrete in front of the splice was thickened so as to give a greater area for carrying stress. The concrete for these walls was mixed to a mushy consistency, using 1-in. stone and 1 : 2 : 4 proportions. The exposed surfaces were rubbed up in a manner similar to the outside wall, so as to leave a rough finish without board marks.

## Tunnels.

The 30 Spectators' Tunnels are 7 ft. high and 8 ft. wide, and average about 140 ft. in length. The design is as shown in Fig. 2. They are paved with 6-in. granolithic pavement and each is lighted with five 100-watt incandescent lamps. The side walls and roof are reinforced, the walls being 15 ins. thick and the roof running from 8 to 15 ins., according to the load. The method of construction was to build the footings of the side walls first, then the side walls and then the roof. Contraction joints were constructed about every 30 ft. of the length of the tunnels. The roof was waterproofed by three layers of Barrett Specification tarred roofing felt and one layer of tartex, mopped with pitch between each two layers and on top. This waterproofing was carried down the sides to a point below the bottom of the roof slab. The side walls were smoothed up with mortar or grout and then given one mopping of pitch. This work was done very well, and leaks have occurred in extremely few places. A layer of mortar, 1 in. thick, was placed over the waterproofing on top of the tunnels as a protection during backfilling.

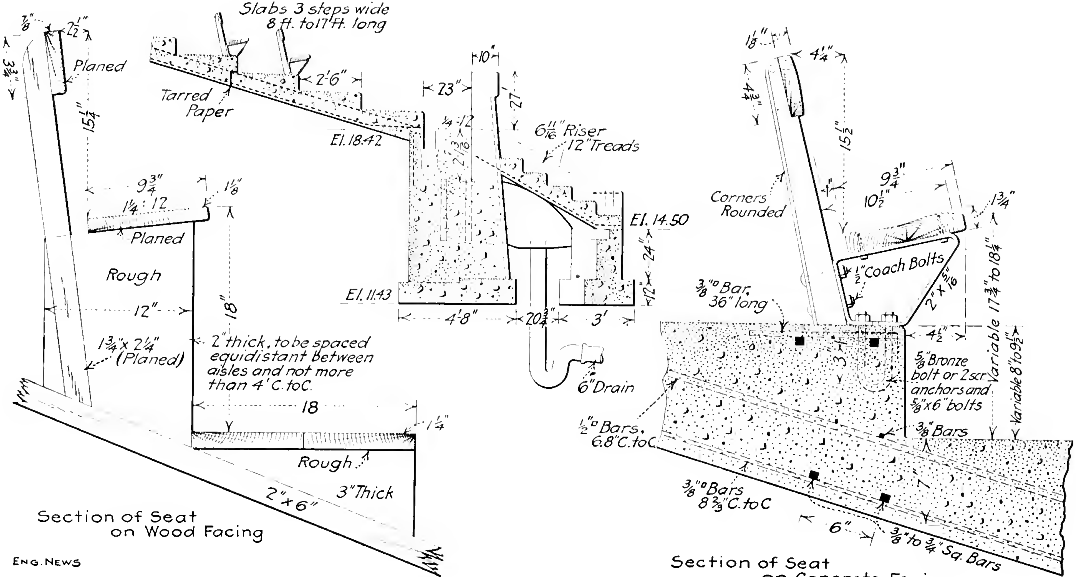
The Main Tunnel and Players' Tunnel were built in a similar manner to the Spectators' Tunnels, the Players' Tunnel being 10 ft. wide and 8 ft. high, with sides 18 ins. thick and roof from 9 to 24 ins. thick, while the Main Tunnel is 15 ft. wide and 10 ft. high, with sides 18 ins. thick and roof 12 to 32 ins. thick. The floor of the Main Tunnel, which was intended for vehicular traffic, is 8 ins. thick, with the surface scored in 5-in. squares.

The inclination of this tunnel is 6.3 per cent. from the horizontal, while the Spectators' Tunnels are built on different inclinations from 0.2 per cent. to 4.3 per cent. The Main and Players' Tunnels are waterproofed in a similar manner to the Spectators' Tunnels. The Main Tunnel carries a load of 32 ft. of earth on its roof in the deepest place, and a sewer drain was laid through this tunnel at a depth below its inside bottom varying from 7 ft. at the inner end to 20 ft. at the outer end. No settlement of the side walls due to the sewer trench was noticed until 27 ft. of the fill had been placed over the tunnel, when settlement began and continued for several weeks and then stopped. The maximum settlement was about ¾ in. This was manifested in a sliding at the contraction joints, but caused no cracks affecting the strength of the structure. The water pipe serving the interior of the structure is carried through this tunnel in a trench built in the concrete floor so that, in case of any possible breakage, no harm can come to the tunnel or to the embankment above it. This trench is covered by a reinforced concrete slab and has the same appearance as the remainder of the tunnel. The inner ends of all tunnels are surrounded by heavy parapet walls, 15 ins. thick, thus carrying out the idea of massive simplicity characteristic of the entire structure.

## Seating Structure.

The seating structure consists of reinforced concrete slabs placed directly upon the embankment, on which are placed wooden benches supported by steel standards. The concrete is placed in the form of steps, and in small independent blocks. These blocks are, except at the cross aisle, three steps, or 7½ ft. wide, and of varying lengths not usually exceeding 13 ft. and running from this down to 9 ft. A few such slabs were built up to 17 ft. in length. The slabs are 6¾ ins. thick at the minimum section, reinforced both top and bottom and in both directions in such a manner that they will support themselves if the sand underneath settles so that they rest on two edges, or are supported in the middle with two edges unsupported. (Fig. 3.)

The reinforcing was made up in mats, one for the top of the



Slabs 3 steps wide 8 ft. to 17 ft. long
Tarred Paper
Planed
Rough
2" thick, to be spaced equidistant between aisles and not more than 4' C. to C.
1¾" x 2¼" (Planed)
2" x 6"
3" Thick
El. 18.42
El. 11.43
El. 14.50
6 11/16" Riser 12" Treads
6" Drain
Corners Rounded
3/8"⌀ Bar, 36" long
½" Coach Bolts
5/8" Bronze bolt or 2 scr. anchors and 5/8" x 6" bolts
3/8" Bars
½"⌀ Bars, 6.8" C. to C.
3/8"⌀ Bars 8 2/3" C. to C.
3/8" to ¾" Sq. Bars
Variable 17¾" to 18¼"
Variable 8" to 9½"
Section of Seat on Wood Facing
Section of Seat on Concrete Facing
Eng. News


Fig. 3.

slab and one for the bottom, while the bars running through the corners of the steps were placed separately. Special reinforcement was used around the bolts for holding the seat standards. Havemeyer bars were used entirely in the reinforcing work. Tarred paper was used to separate the blocks along the circumferential joints, and the radial joints were coated with tar. An expansion joint was provided in the center radial joint between each pair of tunnels. This consisted of a sheet of Carey's "Elastite," a material made up for joints in concrete pavements by placing a layer of bituminous material between two layers of tarred felt, the whole being $\frac{3}{8}$ in. thick and quite elastic. The sheets were cut at the mill to fit the steps.

The concrete was given a $\frac{1}{2}$-in. mortar finish on both treads and risers. The mortar was colored with lamp black to a dark blue stone, so as to relieve the glare. This finish was placed integral with the concrete and troweled to a smooth, hard surface, the forms being removed from the risers as soon as possible, and before they had reached a hard set. The blocks were placed alternately on the checkerboard system, it being necessary in order to make the speed required that they should be placed alternately up and down the slope as well as in horizontal lines. The aisles were given a surface treatment of the concrete hardener made by the Trus-Con Laboratories. The average day's run when working to good advantage was about 30 blocks, or nearly 100 cu. yds. This was done with a force of about 30 men and 3 horses on mixing and placing, and about 17 finishers and 9 helpers on the finishing. The finishers worked until all of the treads were finished on the blocks put in each day. The risers of blocks placed in the afternoon were left until the following morning before finishing.

## Temporary Wood Facing.

The concrete facing was carried only up to the approximate level of the original ground, so as to allow time for the embankment to settle, but the full seating capacity was provided by placing temporary seats on the bank above the concrete. Two in. × 6-in. wood sills were laid up and down the bank, the 3-in.

wedges placed on these and foot boards nailed to the wedge blocks. The seats were built of 2-in. × 12-in. uprights, $1\frac{1}{4}$-in. × 10-in. seat boards, 1-in. × 4-in. back boards supported on 2-in. × $2\frac{1}{4}$-in. standards, all dimensions given being in the rough. The seat boards, back boards and back standards were planed.

The treads of the steps were all 30 ins. wide, more space than usual being necessary on account of the seat backs. The clear space between the back of one seat and the front of the next is $15\frac{1}{2}$ ins., giving sufficient room so that as a rule people can pass in front of those sitting without causing them to rise.

## Concrete.

The concrete aggregate was broken trap rock, obtained from a quarry about two miles north of the Bowl, and sand obtained from the excavation. The cement used was Nazareth Portland cement, furnished under the autoclave test. The proportions used in the reinforced concrete retaining wall and in the seating structure were 1 : 2 : 4 with 1-in. stone; in the outer and inner retaining walls and tunnels the proportions were 1 : 3 : 5 with partly 2-in. and partly $2\frac{1}{2}$-in. stone.

The plant used for most of the tunnels was located in the center of the Bowl, with radial track running to the individual tunnels, the cars being hauled up on top of the tunnel forms. The plant for most of the outer retaining wall was located on the site of the Smaller Gate House, the mixers being elevated and discharging into cars running on a trestle built outside of the wall. The walls and tunnels adjacent to the Main Gate House were put in from a plant located on the site of the Main Gate House and consisted of a Marsh-Capron 1-yd. mixer, hoisting tower and chutes. The same plant was used for the inner retaining wall and the concrete seating structure by laying a track around the interior of the Bowl just above the inner ends of the tunnels and chuting the concrete from the tower into cars on this track, and from the cars into place.

## Permanent Seats.

Considerable study was devoted to the permanent seats, and the design adopted was a wooden bench consisting of a plank supported on the edge of the concrete step by overhanging galvanized steel brackets, and provided with a back board supported by wooden standards attached to the same brackets. The amount of the overhang is $4\frac{1}{2}$ ins., giving ample room for sliding the feet underneath. The brackets were attached to the concrete by bolts, $\frac{5}{8}$-in. bronze U-bolts being used over the larger part of the structure, although the Richmond Screw Anchor and $\frac{5}{8}$-in. sherardized bolts were used on a part of it. The bronze U-bolts were of Tobin bronze and were annealed to prevent as far as possible breakages due to initial strains in the metal. All steel was galvanized and was given three coats of Billings-Chapin & Company's "Rostnicht," the last coat applied after the seats were completed.

The steel standards were supported on wooden wedges until the benches were completed and both seat planks and back boards lined up, and were then grouted with Portland cement mortar, mixed 1 to 2. The grout was not allowed to dry out, but was kept moist for at least a week after being poured.

The top of the seat is hollowed out in a special curve, to give greater comfort, and the front of the back is rounded. This shaping of the wood is a special feature, never before attempted on such seats so far as known, and is expected to add greatly to the comfort of the occupants, a matter of no small importance when it is considered that a large portion of the spectators will occupy their seats for three to four hours. This was secured without expense by being done in the mills when the boards were first planed, it being nearly as easy to plane the boards with curved knives as with straight knives. Many experiments were made to determine just what curves were best for the seat and the back boards, and just the proper angle at which these should be placed to give the greatest comfort to the average human being, and the result has been most favorably commented upon.

The lumber used was Douglas fir from Oregon, and was selected especially for the reason that vertical grain wood could be obtained, thus almost entirely eliminating splintering up of the seat boards. It was found upon investigation that vertical grain lumber could be obtained in only three woods: Douglas fir, western hemlock and Noble fir mixed, and redwood. The western hemlock and Noble fir, which are similar woods and are as a rule supplied together as one kind, could not be gotten out in sufficient quantities to supply our needs in the time available. The redwood was eliminated on account of its liability to stain clothing when wet. The Douglas fir seemed to possess the good qualities required and to be nearly as durable as redwood, and stronger. The only objection to it is the occasional occurrence of pitch pockets. These pitch pockets can be practically done away with by kiln drying the wood, the pitch being boiled out during the process, and this method was adopted with very satisfactory results.

The lumber was supplied by the Eastern and Western Lumber Company, of Portland, Ore., through their local agents. The question of what, if any, preservative to use on the lumber was given much study, it being desired to keep the natural beauty of the wood, and hence to use either oil or varnish rather than paint. There was not sufficient time available to make long time tests on these materials, but samples of the wood were coated with several oils and varnishes and exposed to the weather for a few weeks, and such observations as were possible made upon them. The oils used were linseed oil and three different brands of prepared china wood oil. Three brands of spar varnishes were also used. The linseed oil was rejected because it left the surface of the wood rough and in a condition to catch dirt so that the boards assumed a dingy appearance, which was not desirable. One of the brands of prepared china wood oil had much the same effect, but the two other brands seemed to be very good, and dried with a gloss about like a very thin coat of varnish, and seemed to fill the pores of the wood, leaving a smooth hard finish which resisted sticking of dust, and was easily cleaned. Two of the spar varnishes gave a similar result, but cost between three and four times as much, and there seemed to be some doubt amongst the makers as to whether any spar varnish would stand the severe exposure to which these seats would be subjected, and last a sufficient length of time to make it pay to use them. The comparative cost of the china wood oil and the high-grade varnish was about 75 cents and $2.50 per gallon respectively, and the spar varnish was more difficult and more expensive to apply. While we were unable to find any similar place where china wood oil had been used, still it is well known as the base of waterproofing paints and spar varnishes, and the indications seemed to be very good that it would prove to be about as durable as spar varnish in this location, and at any rate would waterproof and preserve the wood as well as anything, and would furnish a good foundation upon which to apply varnish or paint later if it proved that one of these would be better. The final decision was to use two coats of china wood oil, using the two brands which seemed on the preliminary test to be satisfactory. The first coat was applied before the seats were put in place and the second coat afterwards.

A number of seat planks in the most exposed places were coated with various combinations of the oils and varnishes noted above, and a record kept so that by the time the remainder of the permanent seats were placed, or when it became necessary to recoat those already placed, we might have the benefit of long time tests on all of the materials which seem most likely to give good results. At the end of one year the sample planks were carefully examined and it was found that none of the oils and varnishes had withstood the weather, the sample coated with the china wood oil being fully as good as any. The summer sun seems to be the test which none of the coatings will stand. As the seats were in need of further protective coating, they were again coated with the china wood oil on the upper surfaces. The surfaces which were not exposed to the sun were in as good condition as when originally done.

The temporary seats were not oiled, as it was expected that they would be used only for one game.

## Seating Capacity.

The total number of seats is 60 815 in the main structure, with 244 in the press stand, making a total of practically 61 000. Owing to the great demand for seats at the opening game, a special temporary stand was erected on the promenade around the top of the Bowl, giving an increase in capacity of 7 522 seats, making the total capacity about 69 000, which is believed to be very much larger than ever before attempted. The space allowed for each person averages about 18 ins., the minimum space being $17\frac{3}{4}$ ins.

## Press Stand.

The press stand seats 244. It was erected at the middle of the west side at the top of the bank, where there could be a special stairway to the outside so that messengers could be sent back and forth without disturbing the spectators. This was built entirely of wood, and high enough so the reporters could write their descriptions on the table provided, without danger of the spectators in front of them cutting off their view by standing up. Two rows of tables and benches were provided, with standing room for messengers and assistants. Adequate telephone and telegraph facilities were also installed.

Behind the press box a special stand was erected for the photographers, accommodations for 40 being provided. This consisted merely of a platform with table sloped towards the field so that cameras placed directly on it would be pointing at the center of the field. The table was omitted at one point so that circle cameras could be set up on tripods.

## Architecture.

The architectural features of the Bowl are exceptionally effective in their remarkable simplicity. The purely architectural features are the Main Gate House which faces the junction of Chapel Street and Yale Avenue, and its complement, the Smaller Gate House, on the opposite side of the Bowl. Neither gate house has yet been built, and the following information is taken from the drawings. The Main Gate House is to be 96 ft. × 47 ft. in plan and 42 ft. high. The ground floor is a large lobby leading to the Main Tunnel, the main approach to an exit from the playing field. Stairs lead to the second floor, where ample quarters are provided for the home team and for the ticket department.

This building will be flanked on either side by massive stairways leading from the top of the embankment to the ground below. These are intended to be used as an exit for people walking around the promenade after the games.

The Smaller Gate House is to be 60 ft. × 43 ft. in plan and 27 ft. high. The ground floor is a lobby leading to the Players' Tunnel, which also leads to the playing field. Stairs give access to the second floor, where quarters are provided for the visiting team.

These buildings are designed in a free adaptation of a Roman style of architecture, and set off the rest of the Bowl in an appropriate and pleasing manner.

## Flagpoles.

The only decoration of the Bowl on the day of the first game consisted of two large flagpoles, from one of which a Yale flag was flown and from the other a Harvard flag. This further carried out the general idea of simplicity, and made a very effective finish to the structure.

## Water Supply System.

The water supply is obtained from the mains of the New Haven Water Company by a 6-in. cast-iron pipe running from Chapel Street into the interior of the Bowl. Four-inch cast-iron lines supply water to eight 3-in. Ludlow flush hydrants around the playing field. A 4-in. line is laid entirely around the outside of the Bowl, with 2-in. outlets opposite each tunnel entrance.

## Drainage System.

The drainage outside of the Bowl is taken care of by merely sloping the land to the adjacent streets. The outside slope of the embankment drains to a gutter in the top of the outside wall, and running through a pipe laid in the wall to a drain around the outside. This drain is 8 and 10 ins. in diameter and connects into the main drain in front of the Main Gate House. The inside slope of the embankment drains over the concrete to a gutter in the top of the inside retaining wall, outlet being given at each aisle by a short pipe discharging beneath the steps leading to the field. The water is received on a concrete slab occupying the whole space under the steps, from the center of which a drain pipe leads to the drain laid around the field, concentric with the retaining wall. This pipe around the field varies from 8 to 12 ins., and then discharges into the main drain, which is laid across the short axis of the ellipse. The main drain increases from 15 to 24 ins., and discharges into the West River. The water which falls on the playing field drains towards the retaining wall around the field, reaching a sod gutter next to the wall and discharges on to the concrete slab under the steps and thence into the drains, as noted above. All drain pipes are of vitrified clay tile. All drain inlets are covered with a pyramidal cast-iron grating. So far, the drainage system has worked perfectly, except for a few stoppages in small pipes due to construction.

## Playing Field.

The playing field had to be built on a pure sand foundation, 28 ft. below the natural surface of the ground, and to be put in shape to play upon less than three months after it was completed. The first problem was to so construct the field that sufficient moisture would be held in the loam to prevent the grass from burning out. This was done in two ways: first, by using 18 ins. of black loam; second, by harrowing into the top three inches of loam an inch of fertilizer humus, a natural leaf mold obtained from East Lexington, Mass., to which certain fertilizing chemicals had been added. This humus has the property of retaining moisture a long time.

The next problem was to see that water from rain storms would not stand upon the field so as to interfere with the playing. This was met by crowning the field slightly, the center of the field being made 12 ins. above the turf at the walls, 5 ins. of this crown being between the center of the field and the side lines of the gridiron, a distance of 80 ft. This shape was effected by a special design which gives as rapid a slope as possible near the center of the field without using a straight grade from the center to the sides, which is liable to settle so as to produce hollows. The shape adopted has worked out very satisfactorily, the water draining away with sufficient rapidity and there being no hollows which collect water. At the same time the slope is not sufficient to be noticeable to the eye or to the players.

The field was built with great care, sub-grade being smoothed up 18 ins. below the finished grade and 8 ins. of black loam being then spread and rolled with a 5-ton roller. Sufficient loam was then put on to roll down to just under 17 ins. above sub-grade, and the surface was then trimmed and rolled to a uniform depth of 17 ins. An inch of fertilizer humus was then placed and harrowed in with a cut-away disk harrow, and raked with hand rakes until smooth and fine. A 2-in. layer of turf was then placed and rammed to a firm bed, and screened loam and compost was scattered over the surface, raked in and seeded lightly. This work was done during August, and the field was left to itself, except for watering and cutting grass, until the end of October, when a 5-ton roller was put over it before any football practice was allowed. Light practice was held several times during November, but it was not possible to use the roller again on account of the large amount of rain. The above description applies to the playing field except for a space 25 or 30 ft. wide next to the inner retaining wall, which was necessary to reserve as working space for the contractor. This part of the field was completed and turfed about the first of November. A good proof of the value of the design and the care with which the work was carried out was found in the condition of the field when the first game was played, November 21, as two storms with a total precipitation of 3 ins. had occurred during the preceding week, the second stopping only about thirty hours before the game was played, yet the field was in good condition over seven eighths of the area, the other one eighth being slightly soggy, probably because it had not previously been thoroughly soaked. No trouble was found in securing a good, healthy growth of turf without an excessive watering.

## Toilet Facilities.

Realizing that a crowd of 70 000 people at some distance from regular toilet conveniences would need a considerable amount of such facilities, 8 temporary buildings were erected, 4 each for men and women, providing accommodation for 500 men and 100 women at a time. Conspicuous signs were placed upon the roofs, and their location was shown plainly on the plan sent out with the tickets showing the field and its surroundings. The crowd seemed to appreciate the facilities and they were used extensively. The women's toilets, especially, about which there had been some question, were used by actual count by 5 000, and men's toilets by a much larger number, but no attempt was made to count the men.

## Walks.

The original plan contemplated a concrete promenade on the top of the embankment and a concrete walk around the outside to give access to the various tunnels. For the present, however, it was decided to use a broken stone walk in both places, and this was designed to be 2 ins. thick, of $\frac{3}{4}$-in. stone, to be rolled and then sprinkled with stone dust so as to fill the voids. Placing this thin layer of broken stone directly upon loose sand and gravel seemed somewhat hazardous, but as it was likely to be replaced by concrete later it was desired not to put more expense into it than was necessary. The walk has proved very successful, however, so much so that when left unguarded after the game it became used as an automobile speedway, and prompt measures had to be taken to stop this traffic or the walk would soon have been destroyed.

## Exterior Grading.

The elevation of Chapel Street north of the Bowl made it desirable that the ground between the Bowl and the street should be cut down about 10 ft., and also to a considerable depth between the Bowl and Yale Avenue. Yale Avenue was graded as part of the contract work, and was surfaced with about 3 ins. of yellow loam, which bound the gravel together and gave a fairly good surface after it had been rolled several times. Between these streets and the walk around the Bowl 18 ins. of loam was placed, 12 ins. of yellow and 6 of black, ready to be

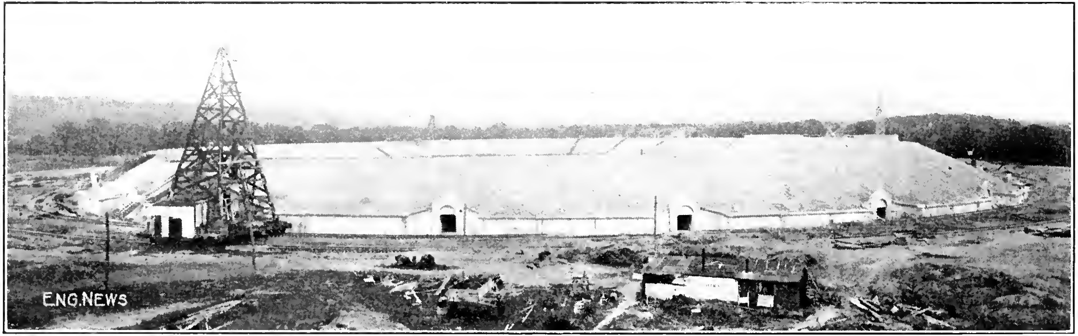



FIG. 4.

seeded down to form a grass plot. The surplus material from the Bowl and the surrounding grounds was carried east of Yale Avenue to a meadow between the high bank and the rectified channel of the present river, where a space of some twelve acres was converted from swamp into good land, which is intended to be used eventually as a parking field for automobiles. This could not be so used the first year, as there was not sufficient time to grow grass upon it, although 6 ins. of loam was put over the surface for this purpose. The rains which occurred just before the game softened the surface of the ground too much to permit parking machines on it. This ground is available not only for parking automobiles, but for all kinds of athletic purposes, and will doubtless be so used. The natural drainage from the hill towards the river tends to make the meadow too wet, and this was taken care of by laying agricultural tile drain at the bottom of the bank and connecting it to the river by two lines of 8-in. vitrified pipe. Since this was laid, there has been no trouble with water on the meadow except from such as fell directly upon it.

### Contracts.

The work was divided into three contracts, the first covering the general earthwork, grading, concrete except seating structure, and construction of playing field. The second contract covered the seating structure, both permanent and temporary, and toilet buildings. The third contract covered the loaming of the area outside the Bowl, the macadam walks and drains on the meadow.

### Personnel.

The Bowl, as far as built, was completed during 1914, the work being done under the Yale Committee of Twenty-One, Incorporated, T. De Witt Cuyler, chairman, and the construction being directly in charge of the Structures Committee, David Daggett, chairman.

Several plans were offered the committee, that suggested by C. A. Ferry of New Haven being accepted. James B. French, of New York, was appointed consulting engineer in charge of design and construction, and the first contract was prepared under his supervision. Mr. Ferry was appointed resident engineer. Mr. French resigned in September, 1913, and Edward G. Williams, of New York, was appointed advisory engineer, and has acted throughout in a consulting capacity. Donn Barber, of New York, was consulting architect. In December, 1913, the author was appointed construction manager (later changed to supervising engineer), to take active charge of the work both of design and construction.

All three contracts were let to the Sperry Engineering Company, of New Haven, A. William Sperry, president, and Geo. H. MacLean, treasurer. Mr. MacLean also acted as general superintendent of the work.

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PAPERS AND DISCUSSIONS

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# MOSQUITO EXTERMINATION IN PANAMA AND NEW JERSEY.

By Harold I. Eaton.*

(Presented before the Sanitary Section, November 24, 1915.)

The history of mosquito extermination begins properly with the occupation of Cuba by the United States troops during the Spanish-American War in 1898.

The occupation had lasted only a short time when it was found that the ranks were depleted more by fatal sicknesses than by casualities caused by actual warfare. The most prevalent and the most fatal of these sicknesses was found to be yellow fever, and the members of the American Medical Corps who accompanied the troops immediately began investigations as to its cause. It is unnecessary here to go into a detailed account of these various experiments, as accounts have been published in various journals giving all details of their investigations. The results furnished indisputable evidence that yellow fever was and could be transmitted only by the Stegomyia mosquito, and that transmission was by the transfer of the germ from the blood of a person suffering with yellow fever to another person. Subsequently similar experiments were conducted in the study of

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the Journal.

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the cause of malaria, and it was again found that the mosquito was the only carrier of this disease, the only difference being that mosquitoes of the Anopheles species carried malaria in the same manner that Stegomyia carried yellow fever.

An exhaustive study of the breeding habits of mosquitoes was at once made and a general clean-up of Havana and its environs was entered upon. Col. W. C. Gorgas was at the head of the Sanitary Corps which undertook the work, and the results obtained by the elimination of mosquito-breeding places and of mosquitoes within a radius of several miles of Havana accomplished unexpected results. Yellow fever in a short time was so reduced that it could no longer be called a menace, and equally pleasing results were obtained in the campaign against malaria. Subsequently the same methods were used in the fight against yellow fevér in New Orleans during its epidemic.

Shortly after the United States had definitely entered upon a plan of building a canal across the Isthmus of Panama, Colonel Gorgas was detailed there as chief sanitary officer. It was known that enormous losses had been suffered by the French forces of construction during their attempts at canal building, and that Panama was considered one of the most unhealthful countries in the western hemisphere on account of the extreme prevalence of yellow fever and malaria. It was, therefore, planned to start sanitary operations immediately in order that conditions might be as healthful as possible before any large number of recruits were sent from the United States. Operations started in the fall of 1904, and sanitary measures were taken at points where it was planned that construction should commence. On account of the difficulties of organization and in securing labor, progress was slow the first few months, so that in 1905, when actual building operations were undertaken, yellow fever had not been completely eradicated. In April of 1905 so many Americans were stricken with yellow fever that there was a panic among them to leave the Isthmus. Hundreds did leave, but those who remained saw the end of the yellow fever on the Isthmus in May of 1905, when the last case occurred. In the eleven years since that time, no case of yellow fever has originated on the Isthmus of Panama. After the first two years, malaria was reduced to one fourth of one per cent. among the employees, whereas in the early days of construction, sickness due to malaria of ten per cent. of employees was not uncommon. The method used, of course, was the extermination of mosquitoes by the draining of swamps, screening of water barrels, cleaning and oiling of ditches and stocking of ponds with fish. The cost was large on account of the necessity of active operations during the entire twelve months of the year. Much permanent work was done in installing complete and effective drainage systems. Where it was shown that the cost of maintenance was high enough to warrant it, ditches were lined with concrete, and troublesome streams were diverted into pipes or concrete channels.

The earliest attempts at mosquito extermination in the United States were probably undertaken in the northern part of New Jersey, in the year 1901. At this time, Prof. John B. Smith, of the New Jersey Agricultural Experiment Station, had commenced a study of the habits of the mosquitoes found in New Jersey and had recommended to several cities the various methods of extermination. The town of South Orange appropriated $1 000 for mosquito extermination in 1901, drained several surrounding swamps and carried on inspection work within the limits of the town with a view to eliminating all breeding places. It was confidently expected that excellent results would be obtained, but unfortunately the habits of the salt-marsh mosquito were not then fully known. It had, of course, been established that the mosquito breeds only in water and that from six to ten days elapse between the time the eggs are laid to the emergence of the winged mosquito. The "wrigglers" seen in rain barrels and pools of water had been identified as larvæ of the mosquito, but little was known of the habits of the adult, its range of flight, etc. It was commonly believed that the mosquito lived only a few days and that it flew very short distances from its breeding place. After spending the money appropriated for local work, the people of South Orange were, therefore, immensely surprised to find the town filled with mosquitoes during the early days of June. This condition continued sporadically throughout the summer months, and mosquito extermination suffered a considerable set-back on account of the inability to obtain results.

Professor Smith continued his investigations, however, and in 1903 determined that the portions of New Jersey within twenty miles of the coast which was bordered by salt marsh suffered from migrations of varieties of mosquitoes bred only in the pools existing on the salt marsh. Two varieties of mosquitoes, known as the Aedes cantator and Aedes sollicitans, were bred in the greatest numbers, cantator being the most troublesome in the early part of the season up to July, when sollicitans predominated, the cantator gradually disappearing until late in the fall. Aedes sollicitans is more widely distributed than the cantator, being found in large numbers in Delaware, South Jersey, New York and Long Island. (Fig. 1.) This mosquito has very distinctive markings, consisting of broad white bands around the middle of the proboscis and longitudinal stripes along the back. The mosquitoes of both the above-named varieties breed only on the salt marsh. As stated before, upon reaching the winged stage they migrate for long distances inland, in some cases as far as thirty-five miles, and for this reason the efforts of mosquito extermination in the cities of northern New Jersey proved unavailing, as only the locally bred mosquitoes were eliminated.

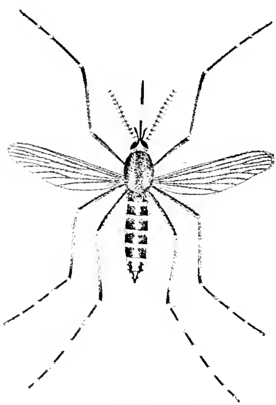


FIG. 1. THE WHITE-BANDED SALT MARSH MOSQUITO. (Aedes Sollicitans.)

New Jersey has approximately 300 000 acres of salt marsh along its coast, extending from Newark Bay on the north down to the extreme point of Cape May and on up the eastern shores of Delaware Bay, the only break in its continuity being about centrally located on the Atlantic seaboard below Sandy Hook.

Professor Smith conducted a careful investigation of the best methods for eliminating the breeding on the salt marshes and advocated a drainage system consisting of narrow ditches 10 ins. wide and 30 ins. deep for draining the water from the surface of the marshes. Subsequent improvements dealing with the arrangement of ditches and the use of dikes have been made since the death of Professor Smith, but the principles of the method advocated by him are in use.

In 1906 the New Jersey legislature passed a law appropriating $300 000 for the drainage of the salt marsh in the State of New Jersey for the elimination of mosquito-breeding places, placing the work in the hands of the New Jersey Agricultural Experiment Station. Unfortunately the entire sum was not appropriated at once, only a small appropriation being made annually by each legislature and the amount of each yearly appropriation left to the discretion of each legislature. Under this system up to 1912 about $110 000 had been expended for the drainage of the marshes, and in amounts varying from $5 000 to $30 000 annually. The work was started in North Jersey on Newark Bay and carried down the coast for a distance of forty miles. Complete drainage systems were not installed, however, as it was hoped that enough interest would be shown by neighboring communities to appropriate amounts sufficient to complete the drainage within that vicinity. This was not done, however, and the full benefits of the work were not secured.

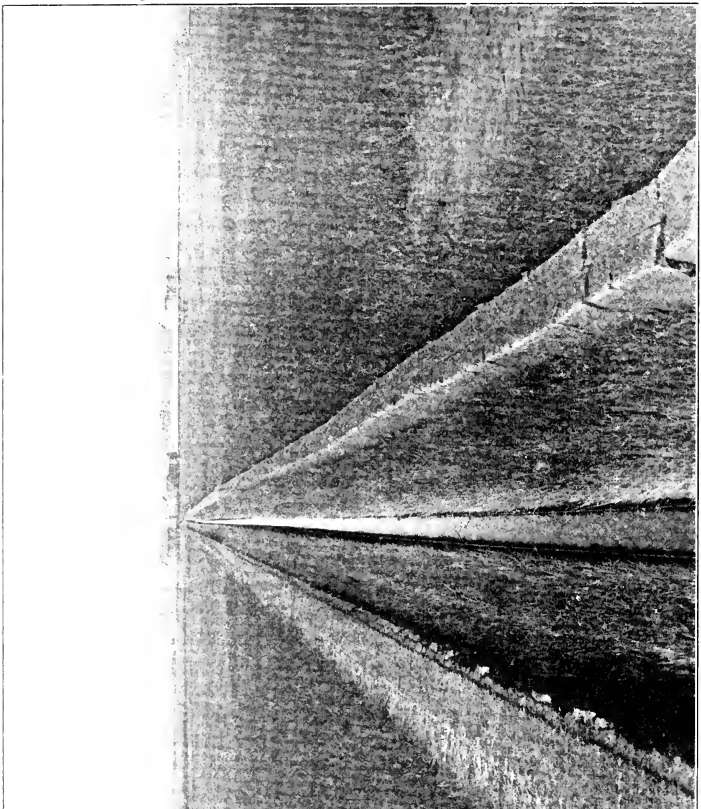
In 1912, another bill was passed by the legislature creating in each county in New Jersey, by appointment of the Supreme Court Justice, a commission of six men whose duty it should be to carry on the work of mosquito extermination in each county with funds raised by taxation. The Director of the New Jersey Agricultural Experiment Station was given oversight of the work in all counties, and given the power of deciding whether or not the work would be of sufficient benefit to a county to justify the formation of a commission and the raising of funds. The amounts which could be raised in the different counties depended upon the density of the population and the amount of resources. In a populous county of over 500 000, the law provided a rate of one eighth of a mill for each dollar of assessed valuation, the amounts thus varying, so that a county of a large area and small population could raise money at a rate of one-half mill on each dollar of assessed valuation. In Essex County, probably the wealthiest county in the state, it was possible to raise, under this law, $75 000 annually for the purpose of mosquito extermination, and in the smaller counties the amounts varied from $10 000 to $35 000. Several counties immediately took advantage of this act to form commissions, prosecuting vigorous campaigns comprising both drainage of the salt marshes and the elimination of fresh-water breeding places.

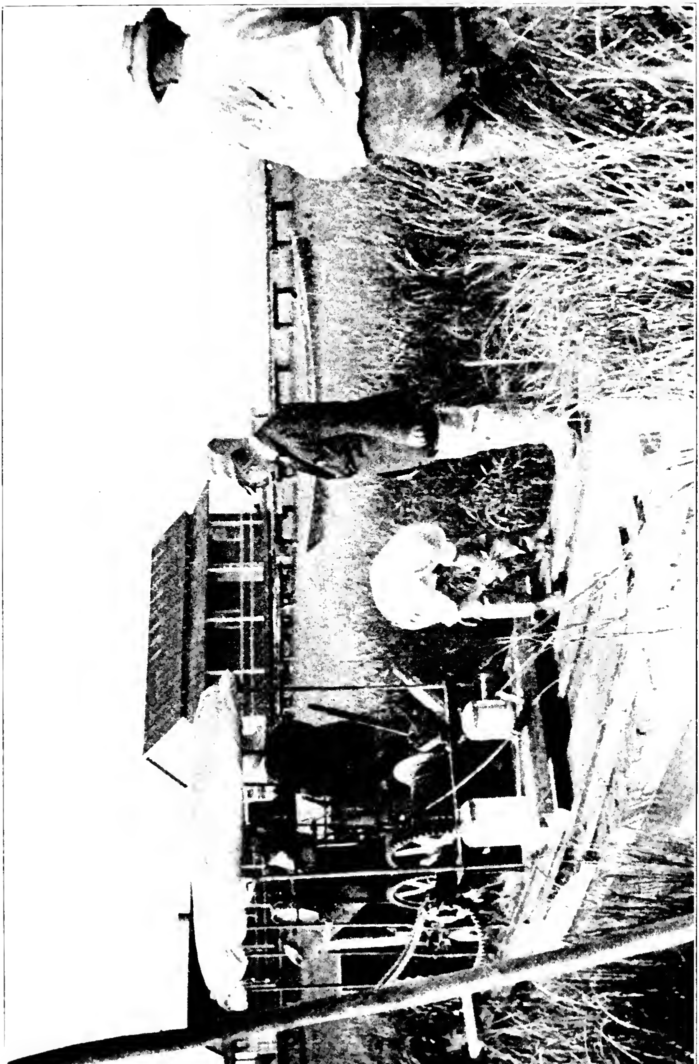
In Atlantic County, in the southern part of New Jersey, a commission was formed in 1913 with power under the law of 1912 to obtain $31 000 annually for carrying on its work. Twenty-six thousand dollars was decided upon as the annual appropriation which would suffice for the work, and drainage of the salt marsh was immediately started. This commission has been in existence three years, and during that time has drained more than 12 000 acres of the 50 000 acres along its coast line. On account of tidal conditions, it has been found that 20 000 acres of this 50 000 will not require drainage, so that there remains to be drained about 18 000 acres. Each summer a corps of inspectors has been organized for locating breeding places of the fresh-water mosquito within the various cities and towns, and the recognized methods of drainage and oiling for their elimination have been used.

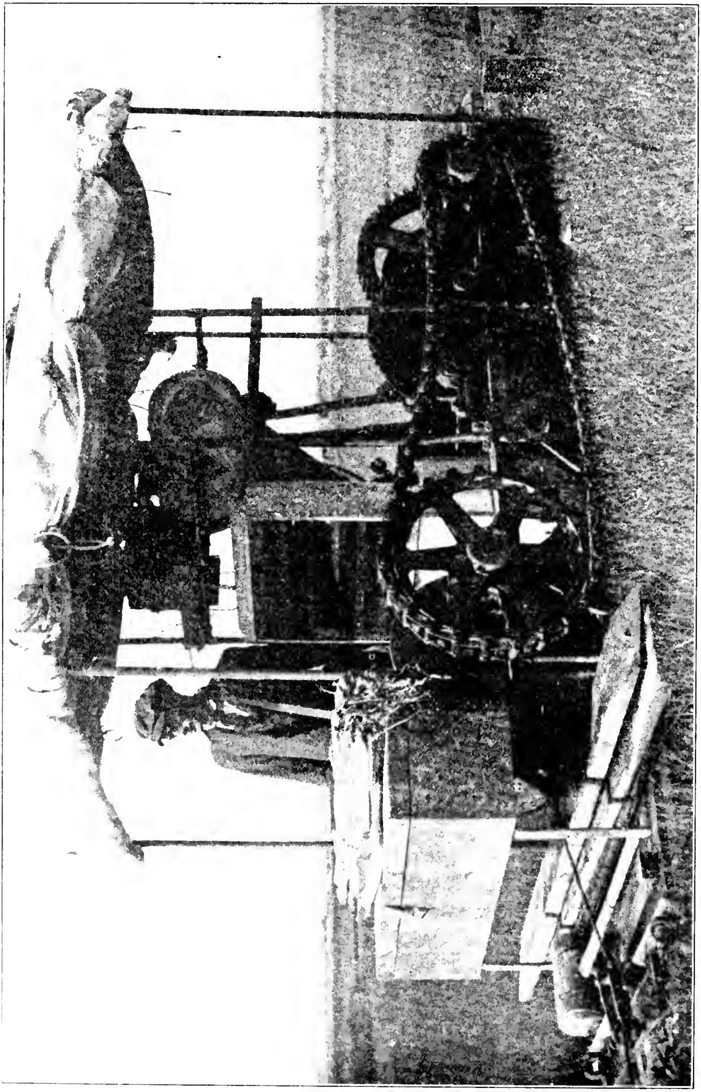
The salt-marsh mosquito, however, is the great problem of Atlantic County and of South Jersey, with the fresh-water problem occupying a place of much less importance. The breeding habits of the salt-marsh mosquito vary from those of the fresh water to a great extent. The female mosquito of the salt-marsh variety lays her eggs in the depressions on the meadow, in the mud around the edges of pools or in the bottom of dry depressions. When these eggs are covered by water of sufficient warmth, the "wrigglers" appear from twenty-four to forty-eight hours later, their growth depending on the weather and the resulting temperature of the water. In the warm weather of July and August the winged mosquito emerges from the pool in from six to eight days, while the time required in the colder weather of spring and fall may be as much as four weeks. As the eggs are all covered with water and hatch into "wrigglers" at the same time, the mosquitoes emerge days later at practically the same time, ninety per cent. of them appearing on the same day. This is the cause of a sudden and overwhelming "crop" of mosquitoes appearing in a community which may have had none the day before. As stated above, the salt-marsh mosquitoes fly with the light winds across the country adjacent to the marsh and can be found at any time during the season twenty-five or thirty miles from the nearest breeding place.

The drainage of the salt marsh being carried on by this commission is performed with the sole object of removing from the surface of the meadow, by effective drainage, the stagnant water in which the mosquitoes breed. The drainage system usually consists of a series of parallel ditches, placed from 125 to 200 ft. apart, this distance depending on the nature of the soil and vegetation, which determines the porosity of the meadow and its adaptability to drainage. A deep creek or stream is used as the outlet of the ditches to insure the emptying of the ditch at low tide. Where a natural creek is not available, and where the bay shore is too far away, an outlet ditch is dug 20 to 30 ins. wide and 30 ins. deep. As it requires at least seven days for the eggs to become mosquitoes, the drainage system is planned to remove the water from the surface within three days, so that the "wrigglers" cannot hatch into mosquitoes. Each ditch drains the meadow on each side of it for a distance of 60 to 100 ft. Where a deep pool or depression is found, a short spur ditch is dug from the pool to the nearest ditch. This allows the tide to flow in and out, insuring a constant change of water and giving admission to the small minnows which feed on mosquito "wrigglers."

Several varieties of implements have been used by the commission in the digging of these "mosquito ditches." The first method employed was the contract system, under which contracts were let in amounts of about 200 000 linear feet at prices varying from 2¼c to 2½c per foot. The contractors, in performing the work, used patented spades operated by two







or three men. At one cut a spade would remove a block of sod 30 ins. deep and 10 ins. wide and about 10 ins. along the length of the ditch. A power machine was used by one of the contractors, which cut out sods in substantially the same manner and the same dimensions.

In 1914, the commission decided to do its own ditching with machines known as the Eaton Ditching Machine, the principle of which differed considerably from those of the implements then in use. With this machine the sods were removed in long continuous strips somewhat after the manner of a furrow cut by a plow, except that the strips were 10 ins. in width and 15 ins. in depth and the material of 30-in. depth removed at one cut and thrown on both sides of the ditch. Under this system the ditch cutters are pulled toward the hauling machine anchored 500 ft. away on the marsh, and, as the cutter travels at the rate of about 30 ft. a minute, 500 ft. are cut in fifteen minutes. The hauling machine then pulls itself ahead 500 ft. by the use of anchors carried ahead, and the operation is again repeated. In this manner the cost of ditching in Atlantic County has been reduced to about $\frac{5}{8}$c. per linear foot and the funds of the commission have been sufficient to drain a much larger area than would have been possible under the more expensive contract method. The machine ditching is supplemented with hand ditching to complete the drainage in various areas, and the cost per acre for complete drainage under the present method has been found to average about $4.00.

The results obtained by the drainage of only a portion of the salt marsh within the county have been better than anticipated, as certain localities which are about centrally located with regard to the drained meadow have been free from mosquitoes the greater portion of the season, receiving only occasional invasions of mosquitoes bred on the marshes several miles distant. It is not expected that complete results will be obtained until all the marshes within the county limits have been drained, and even then we may expect occasional invasions from the mosquitoes bred on the marshes of neighboring counties which at present are not drained. Indications are, however, that these marshes of the adjacent counties will be drained either this year or next with funds raised within the counties, under the law of 1912, or with funds contributed by the state, remaining under the law of 1906. The work will require several years for completion, but the number of salt-marsh mosquitoes will decrease each year as the work is extended, and the results obtained when the work is finally completed will be well worth the time and money expended. Freedom from mosquitoes in Atlantic County and South Jersey will be of untold benefit both to the shore resorts and the agricultural communities, whose development is checked solely by the devouring summer hordes of salt-marsh mosquitoes.

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PAPERS AND DISCUSSIONS

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# REFORM AND REGULATION.

By Alexander C. Humphreys,* M.E., Sc.D., LL.D.

(Presented April 21, 1916.)

It is practically impossible to discuss any moot question of importance without being misunderstood. Those who strive to preserve the balance between two extremes are almost sure to be misunderstood and misquoted by the adherents of both extremes.

As far as possible, let me anticipate this difficulty, which stands in the way of a fair and reasonable discussion of the questions involved in the regulation of public utilities, by the statement of my proposition.

While, on the one hand, quasi-public corporations should be required to submit to regulation under governmental authority, on the other hand this regulation should not be so overdeveloped as to deprive the officers of these corporations of the opportunities to employ completely their initiative in the interests both of the investors and the public served. Undoubtedly, under the present-day conditions, the need for regulation had become apparent. A comparatively few of these public service corporations through their unwisdom had helped to create the demand for more onerous regulation; they developed in the public mind

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before August 10, 1916, for publication in a subsequent number of the Journal.

* President, Stevens Institute of Technology.

a spirit of antagonism which has worked to the injury and prejudice of the great army of corporations which are ready and willing to conduct their affairs for the best interests of all concerned.

To obtain the best result for all concerned, coöperation between the several interests is a prime necessity. No real coöperation can be secured where there is antagonism between the parties in interest. If one side is likely to be the aggressor, the other side must be prepared for defense.

Under an autocratic government both sides can be driven to work coöperatively in the interest of maximum economy and efficiency. But ours is not an autocratic government; theoretically, at least, it is a government of the people, by the people and for the people.

Are we not looking for more than is obtainable from a democracy? Should we not recognize that, for the liberties we enjoy, or are supposed to enjoy, under a democracy, we must pay a price in the sacrifice of some of the material efficiency which can be secured under an autocracy? This price must be paid, and always will have to be paid, so long as human nature is what it is. As in every other mundane problem, a balance has to be established between the advantages and disadvantages. But this does not mean that we should not be continually vigilant and persistent in our activities to bring the price down to the attainable minimum; particularly the effort should be to prevent the price from being increased with the years. While it devolves upon all the people to be keenly solicitous for the elimination of the bad and the development of the good in our civic and national life, we must avoid the error of believing that good intentions alone are a sufficient qualification for leadership in reform movements.

Those who confidently and light-heartedly assume the grave responsibility of undertaking to reform anything or everything which excites their disapprobation may, through their Incompetence, easily develop other and more dangerous conditions than those which they have, perhaps honestly, been trying to correct.

The New York *Sun* in a recent editorial described a condition of mind which has been of late much in evidence in this country, and particularly in high places: "A psychological affliction that clothes hopes in the raiment of fact and translates altruistic ambitions into accomplished ends."

Dr. Henry S. Pritchett, in a recent address, voiced a truth which we might all do well to keep continually in mind: "The world is full of devotion; but the devotion which thinks clearly, which has a true perspective, which can reckon with time, is rare."

Unquestionably our country has suffered much through the activities of those who, with honest intentions, have been conspicuously unqualified, or positively disqualified, to effect constructive reforms. If we confine our consideration to results alone, it is not improbable that the country has suffered as much from the ill-directed zeal of these honest but self-sufficient enthusiasts as from the cunningly directed activities of the reformers for personal profit. Those of the first class win the support of the credulous and uninformed through the very fact that they are credited with being personally honest and disinterested. In trying to differentiate between these two classes it is well to appreciate that there are those who, while personally honest, are mentally crooked.

Under our form of government it is necessarily difficult to preserve a just balance between those who in actual practice are governed and those who are elected or chosen in one way or another to govern. Here a great responsibility rests upon the specialists in political economy. And, I fear, it is true that if the account could be completely written up, debits and credits, we should find that many of these men have added heavily to the price we pay for our democracy. And is this not the natural result of the teachings and influence of men who attempt to qualify as leaders of their fellows by studying each others' books while neglecting that great educational agency which none can safely neglect,—the school of human experience? Thus we find that many of these inexperienced schoolmen are intellectually the inferiors of those they assume to instruct and lead.

The result of the activities of these enthusiasts, dishonest reformers and inexperienced schoolmen has been the enactment of a multiplicity of laws and the strained interpretation and enforcement of laws old and new; and this result not infrequently has evidenced a desire to punish rather than an unselfish purpose to develop better conditions. The multiplying of the laws, apart from the question of their content, is an evil to be controlled.

In an address delivered some months ago, Elihu Root condemned this national weakness. He said in part: "We make too many laws. Our national and state legislatures passed 62 014 statutes during the five years from 1909 to 1913 inclusive. During the same five years 65 379 decisions of the national and state courts of last resort were reported in 630 volumes. Of these laws, 2 013 were passed by the National Congress; and of these decisions, 1 061 were rendered by the Supreme Court of the United States. Many of these statutes are drawn inartistically, carelessly, ignorantly. Their terms are so vague, uncertain, doubtful, that they breed litigation inevitably."

Here is a warning delivered by a man who speaks from a wide and special experience; a warning coming from such a source we cannot afford to disregard.

This deplorable condition, while rendering general and consistent enforcement of law difficult when not impossible, does offer a weapon to the blackmailers, a weapon which they are prompt to use. Then the amateur reformer again becomes active, and, to cure the non-enforcement or misapplication of these too many laws, agitates enthusiastically for the enactment of still more laws.

Here there is need to control honest but reckless enthusiasts as well as the reformers for personal profit. Let us be true with ourselves and face the fact that too many representatives of both of these two classes can be found in our national and state legislatures.

Examples of the insincerity of much of the reform activities of our legislative bodies can be found, most unfortunately, in the records of many of the special legislative investigations conducted during recent years. Naturally, these investigations sometimes have brought to light transactions which deserved exposure. But this result, which can and should be made to work for good, is too often accompanied by processes and results which are mean and grossly unjust. Frequently these investigations are so conducted as to prevent the development of a complete record. Would it be unfair to say that rarely in such investigations is there a well-sustained purpose to place on the record the truth, the whole truth, and nothing but the truth? A witness is required to take an oath to so testify, but the chairman prevents him from so testifying. And is it not easy to see why these investigations are so frequently a shame to us who permit such conditions to exist? They are frequently set on foot, not to learn the truth wherever that may lead, but to develop a record which can be used to influence voters in favor of the political party responsible for the investigation. Thus those who are earnestly opposed to the corrupt practices sometimes exposed are prevented from giving full support to those exposing these practices because they question the fairness of the investigation. No doubt the question has occurred to many of us, What if the investigators were themselves impartially and effectively investigated?

In many cases, because they are not permitted to tell their complete story, grave injustice is done to many who are required to testify. Witnesses are halted as soon as the point aimed at by the chairman of the committee has been gained. Opinions and statements of fact are taken out of their context. A man who will so conduct an investigation ("the act or process of searching minutely for truth, facts or principles") is far lower in character than many a poor devil imprisoned for some petty crime. And the fault rests with us, for we fail to regard these men as dishonored, and we take them by the hand in real or professed friendship.

A recent example of investigations which do not investigate is the Thompson "investigation" in New York. I quote from a letter recently written by Controller Prendergast of New York City to Chairman Thompson of the committee: "In the statements I have heretofore deemed it necessary to make regarding the subway controversy, I have charged that you have been conducting the investigation in such a way as to distort facts and evade real issues. I have before me, in a statement attributed to you, in a morning paper, absolute confirmation of the opinions I have expressed regarding your work. . . . This statement on your part is a cowardly attempt to give a dishonest twist to the situation." A number of my friends who have been present at the hearings, having no direct interest in the matters at issue, have given me accounts of the methods pursued by Chairman Thompson which justify Mr. Prendergast's vigorous protests.

Another recent example stands out by itself from the many cases which call for the reprobation of all decent men, — the investigation of the Federal Industrial Commission conducted by Chairman Walsh. In at least two cities, *before the opening of the hearings*, this man, in public addresses, showed that his opinions were radical in the extreme and were already firmly fixed. In answer to criticisms of his course, he was reported as saying that he was not of a judicial turn of mind and he proposed to conduct his "*investigations* " on the basis of the opinions he already held. Think of such a man being appointed to conduct a vitally important nation-wide investigation, and think of the humiliation of those who were willing to continue to serve on the commission under such unworthy leadership and to accept their share of the responsibility for his demagogy! Think of the responsibility resting upon those who appoint such men to positions of such tremendous influence for good or ill to the country at large! Such a man as this chairman is incapable of understanding that the maximum of progress, both as to rate and permanency, is secured only by the retention of all elements which have successfully met the test of years. True progress means conservation of all the good, and elimination of the bad only. Our present-day reformers are too ready to pronounce as bad, on the score of age alone, all that has so met the test of years.

Now it may be thought that I am charging too much that is inefficient or evil against democracy. I am endeavoring only to point out the evils to be avoided, and also to guard against the belief that we can enjoy all of the advantages of democracy while escaping its disadvantages.

We must also keep in mind the difference between true and false democracy. Nicholas Murray Butler, president of Columbia University, makes this differentiation clear: " Jealousy of power honestly gained and justly exercised, envy of attainment or of possession, are characteristics of the mob, not of the people; of a democracy which is false, not of a democracy which is true. False democracy shouts, Every man down to the level of the average. True democracy cries, All men up to the heights of their fullest capacity for service and achievement. The two sides are everlastingly at war. The future of this nation, as the future of the world, is bound up with the hope of a true democracy that builds itself on liberty."

Here is our problem: To strive continually for the development and maintenance of a true democracy, and so for our liberty pay as small a price in inefficiency and injustice as conditions permit.

Now how do these deplorable conditions, which I am sure are not overstated, affect the regulation of public utilities by the public service commissions, Federal and State? Here certainly we have had to pay the price for our democracy in loss of efficiency and economy and frequent exhibitions of injustice.

As quasi-public institutions, and under the conditions which control, the public utilities are natural monopolies. As such they should be regulated as far as is necessary to secure compliance with the law; and this being granted, they should be protected in their rights, including that of monopoly. The fact is, however, that the advent of commission regulation has not eliminated competitive raids, with the result that many of the public utilities are laboring under the burden of overcapitalization for which they were not primarily responsible. Many of these raids were initiated in our legislative halls.

As it appears to me, there are two fundamental conditions which should limit the regulation of our public utilities.

First: The initiative of the public service corporations should not be destroyed.

Second: The public service commissions should not be permitted to exercise the three functions of government, — the legislative, the executive, and the judicial.

As to the first we may well keep in mind the teachings of Thomas Jefferson: "Agriculture, manufactures, commerce and navigation, the four pillars of our prosperity, are most thriving when left free to individual enterprise."

As to the second condition, we find that the Democratic platform, constructed at Baltimore in 1912, contains this plank, which simply reaffirms a fundamental principle of our government: "We believe in the preservation and maintenance in their full strength and integrity of the three coördinated branches of the Federal Government, the Executive, the Legislative and the Judicial, each keeping within its own bounds and not encroaching upon the just powers of either of the others."

In the face of this recent restatement of a vital principle by the party now in power, it is discouragingly significant to recognize, as I think we can, that this principle never has been so constantly violated as during the last three years.

As far as I have been able to observe, and I have been keen to watch the trend of events in this connection, the protests made against this violation of a bedrock principle of our government are rare. I cannot see how our form of government can persist in its integrity if this violation of principle is to be permitted to persist. We must choose between the two.

Under commission control, over-regulation and unnecessary interference with individual enterprise has been gaining headway year by year. The tendency to allow this one authority to exercise the three functions of government has been year by year more in evidence. The regulation of business in many cases has developed or, more correctly, degenerated into persecution; and this also applies to business other than that of the public utilities. Perhaps the burden of over-regulation has rested most heavily upon our railroads. The sooner the people as a whole come to understand that upon the prosperity and efficiency of our railroads depends in large measure their own prosperity, the better for all concerned. Sooner or later they will learn whose ox is being gored, but they may not be able to distinguish the aggressor.

The tendency of these commissions, Federal and State, is to get deeper and deeper into the details of management, to become more and more active in legislation and the framing of major and even minor rules, and to be more and more keen to sit as judges in trials of public service corporations.

The annual reports of the Interstate Commerce Commission are enlightening in this and other respects. I commend them to your study.

The last annual report, that of December 1, 1915, states as follows as to the period covered: "Except as otherwise noted, the period covered by this report extends from November 1, 1914, to October 31, 1915." We find that certain data are given for the calendar year, and that the fiscal year is from July 1 to June 30. This is somewhat confusing. The following data are for the year ended October 31, 1915.

Complaints entered on Informal Docket, 6 500, a decrease, as compared with preceding year, of 1 380.

Applications filed on Special Docket, 6 690, an increase of 1 176.

Complaints entered on Formal Docket, 964, a decrease of 190.

| | |
|---|---|
| Cases decided | 902 |
| Cases dismissed | 205 |
| Total | 1 107 |

an increase of 243.

Hearings conducted, 1 543, in which 200 438 pages of testimony were taken, as compared with 1 607 hearings and 179 569 pages of testimony taken during the preceding year.

In this part of the report, this appears: "It might have been expected that as the years pass the decisions of the commission would result in a decrease in the volume of this work, but it has not so developed."

Suspension of Schedules Docket:

Cases instituted, 199, a decrease of 4.

Cases disposed of, 210, an increase of 51.

Special investigations of railroads and other interests:

| | | |
|---|---|---|
| *Concluded:* | Ordered by Congress | 4 |
| | At instance of Commission | 6 |
| *Still open:* | Ordered by Congress | 2 |
| | At instance of Commission | 25 |

There were filed with the commission, tariff publications containing changes in rates, fares, classifications or charges, 149 449, an increase of 418 as compared with the eleven months ended October 31, 1914; an increase of 40 683 as compared with the year ended November 30, 1912; but a decrease of 78 954 as compared with the year ended November 30, 1908, the first year recorded.

For the fiscal years ended June 30, the expenditures were:

| | 1912–1913. | 1914–1915. |
|---|---|---|
| Salaries, Commissioners and Secretary......... | $73 111.10 | $74 277.78 |
| "All other authorized expenditures".......... | 846 003.23 | 998 833.07 |
| Examination of accounts.................... | 297 517.93 | 296 978.31 |
| Locomotive boiler inspection................. | 198 029.15 | 208 393.70 |
| Safety appliance, block signal, and hours of service.................................. | 135 376.47 | 223 517.58 |
| Valuation................................. | •10 366.33 | 2 131 924.74 |
| Totals.............................. | $1 560 404.21 | $3,933 925.18 |

Increase in two years, $2 373 520.97, *of which $2 121 558.41 is on account of valuations.*

This record shows a vast amount of work performed and very wide powers exercised, and yet, in this report, as in previous reports, we find the commission asking Congress for *more work and more power.* And this request is now made to the representatives of the political party of which Thomas Jefferson is spoken of with pride as its "most distinguished apostle."

No seven men could be found who would be capable of doing this great work effectively, efficiently, thoroughly and fairly. Judge Prouty, then chairman of the commission, voiced this opinion in an address delivered in 1907. If true in 1907, it is certainly true to-day.

If these faulty laws, laws giving far too great powers to these commissions, were always or even generally administered with full knowledge and understanding of the facts and conditions, with wise discretion, and with proper restraint; if the commissions concerned themselves only or more particularly with the larger questions of principle and policy, the danger to our vested interests and the country's prosperity would be greatly lessened. But the fact is the commissions more and more concern themselves with and exercise their authority with respect to the details of design, construction, production, management, administration and financial policy. *Thus they exercise* *the authority while avoiding responsibility for final results — a most inefficient and dangerous system.*

While the Federal and State commissions have instituted some much-needed reforms, they have, on the other hand, done much which has been injurious, unnecessarily injurious, to the industrial and commercial life of the nation. If a fair analysis were made of the complete record of their activities, I can hardly believe that the balance would be found in favor of the commissions.

To the railroads of the United States, and so to the pioneers in the development of these railroads, should be given the credit in full measure for their great part in the material development of this country. Undoubtedly the full account would show debits also, but there would be a heavy credit balance. And yet the railroads have been so hampered and hindered by the Interstate Commerce Commission, the state commissions, *and those using the commissions as their tools*, that the railroad situation has been causing deep concern to railroad officials and bankers, and finally is beginning, fortunately, to cause alarm to the innocent small investors in railroad securities.

The report of the Securities Commission, so strong in its membership and so wisely presided over by President Hadley, of Yale, should have been taken more seriously by the commissions and the authorities in Washington. The report of this commission, a report exceptional in its conclusiveness, disclosed conditions demanding prompt and effective remedies. And yet for three years after the rendering of this report, the conditions under which the Interstate Commerce Commission obliged the railroads to operate were even more difficult and oppressive. Recently there has been a little more indication of open-mindedness and courage to act on the facts.

Why is it that the railroads of the United States are so oppressed? Is it because by comparison with other countries our railroads are over-capitalized, exact excessive charges for freight and passenger traffic, afford inadequate facilities and accommodations to its patrons, or underpay its employees? These questions are all explicitly negatived by the facts.

The average capitalization per mile of our railroads is less than one fourth that of England, a little less than one half that of France, and a little more than one half that of Germany. It costs about one third as much to move a ton of freight a mile in the United States as it does in England, and about one half as much as it does in France or Germany. Passenger fares, first-class, are much lower than in either of these countries. The accommodations and facilities offered by our railroads have set the pace for the railroads of Europe.

The average daily wage paid railroad employees in this country is about 65% higher than the wages paid by English railroads, about 150% higher than paid by the French railroads, and about 175% higher than paid by the German railroads.

Do our railroads fail to do their share toward the support of the government?

In 1902 the railroads paid in taxes an aggregate of over $54 000 000, amounting to 8⅓% of their income. Ten years later they were paying over $140 000 000 in taxes, amounting to nearly 16¾% of their income, an increase in the period of almost 160%. This increase of $86 000 000 would pay 5% on $1 720 000 000.

In the rate case argued in Washington about two years ago, it was shown that the average return on railroad capital was less than 4%, while at that time railroads of established credit were paying as high as 7% on the short-time renewals. It is true that this was a time of depression and lack of confidence, but these were conditions due in large measure if not entirely to over-regulation and general interference on the part of government. Conditions have somewhat improved, but this improvement is largely accidental and cannot be credited to changes in government policies or procedure.

Another direction in which the railroads have been unfairly treated is in the carrying of the mails, and particularly in connection with the parcels post. Here the railroads were called upon to render a great additional service without adequate additional compensation. Ex-President Taft, while endorsing this addition to the government's activities, has this to say: "There is one thing connected with the parcels post that ought not to meet the approval of anybody, and that is that we have not given the railroads appropriate compensation for the additional burden that they have to carry by reason of the parcels post," — and then he goes on to say with characteristic optimism, an optimism which has not been justified by the facts, " but after a time Congress will see its duty and make reparation in this regard, I hope." This was said over two years ago, and the railroads are still looking and working openly and intelligently to hasten the time of reparation.

Even President Wilson, in answer to an appeal of the railroad managers, in September, 1913, said:

" You ask me to call the attention of the country to the imperative need that railway credits be sustained and the railroads helped in every possible way, whether by private coöperative effort or by the action, wherever feasible, of governmental agencies, and I am glad to do so, because I think the need very real.

" The interest of the producer, the shipper, the merchant, the investor, the financier and the whole public in the proper maintenance and complete efficiency of the railways is too manifest. They are indispensable to our whole economic life, and railway securities are at the very heart of most investments, large and small, public and private, by individuals and by institutions.

" I am confident that there will be active and earnest cooperation in this matter, perhaps the one common interest in our industrial life. . . .

" But the emergency is, in fact, extraordinary, and where there is a manifest common interest we ought all of us to speak out in its behalf, and I am glad to join you in calling attention to it. This is a time for all to stand together in united effort to comprehend every interest and to serve and sustain it in every legitimate way."

Since writing the above, President Wilson, in a letter to the majority leader of the House of Representatives, has this to say of the proposed investigation with respect to amending the acts regulating the common carriers of the United States:

" The railways of the country are becoming more and more the key to its successful industry, and it seems to me of capital importance that we should lay a new groundwork of actual facts for the future necessary regulations.

" I know that we all want to be absolutely fair to the railroads, and it seems to me that the proposed investigation is the first step toward the fulfillment of that desire."

The pity of it is that the views of the President himself at the time he assumed his high office were in great need of readjustment as to the railroads and all other departments of the country's industries. Furthermore, I can find no sufficient basis for his statement of belief, "I know that we all want to be absolutely fair to the railroads." Was it fair to the industries of the country to appoint Walsh as chairman of the Federal Industrial Commission?

Apparently the "common interest" is not yet "manifest" to those who have the power to regulate and control, nor to those who have the power to change the laws through which these interests are regulated and controlled. In the case of some of those who have the power, the "voice of the people" has not yet indicated to them the need of a change. If that voice thus is heard, those in power will recognize promptly that they have a call to change their views.

If this "common interest" is to be recognized by those in power, the financial condition of the railroads of the country might well be kept in mind. Last fall there was made a study of certain railroad statistics. The result was, to me, startling. Since then, these conditions have somewhat changed for the better, and particularly as to certain properties; but the lesson is still to be heeded.

In 1906, the quotation for railroad stocks averaged about 138. Last fall this average had fallen 48 points. The net revenue had increased about $10 000 000 over the year before, the reduction of expenses showing a reduction of $140 000 000 to $130 000 000. Here we may assume that this reduction, in part at least, is represented by smaller expenditures for maintenance, a dangerous way to save money. One eighth of the railway mileage was in the hands of receivers. In more than one case, stockholders had been obliged to face either an assessment of $50 a share or a total loss of their investment. But this loss did not fall on the stockholders alone, for the average number of railway employees had fallen *in one year* from 1 815 239 to 1 695 483.

We must not forget that the prosperity of the country depends upon the ability of the railways to make extensions and betterments. Here comes in an element which the government and its commissions cannot control — the will of the investors; these people who lend the money to the railroads have the final word. If they are not protected in their property rights in connection with railroad investments, they will not risk more money along the same lines. Of late the total new mileage has been negligible as compared with years past, when the railroads were not so over-regulated. This alone is a great national question.

I have shown that the annual cost of operating the Interstate Commerce Commission increased, from 1913 to 1915, $2 373 520, and that of this increase $2 121 558 was chargeable to the valuation of railroad properties. In the commission's report of December 1, 1915, we are told that there are in the United States about 250 000 miles of railroad, and that with the present force the work on about 45 000 to 50 000 miles a year can be completed. By January 1 this year it was expected that 50 000 miles would be completed, leaving 200 000 miles, the work for four more years. In commenting on this work, the report says: "It seems to be universally conceded that in addition to the amounts obtained by the application of unit prices to the quantities shown upon the inventory, certain additions, commonly known as overhead charges, must be made. These items are of significance, and no opinion should be expressed upon them without the fullest possible information. Here, again, an examination of the accounts of carriers for the purpose of ascertaining what the amounts have actually amounted to in the past is of first importance, nor would it be safe to accept the result obtained from one or even from several carriers."

Again: "Experience indicated that it will be possible to obtain with reasonable certainty those facts called for with respect to the corporate and financial history of the carrier, but that it will not be possible in all instances to give the original cost 'in detail as to each piece of property,' as called for by the act."

It is encouraging to find that the commission has discovered that the valuation project has its serious difficulties and calls for the exercise of a high order of judgment to develop the truth. I venture to suggest that in very few cases can the whole truth be developed as to the "overhead charges" and the financial history by an examination of the accounts. I fear that too much reliance is being placed upon inventories. Those of us who have had to do with the extensions of existing properties, or the construction of plants in which, for instance, street obstructions have had to be dealt with, can understand far better than these commissioners that vast sums are necessarily and legitimately spent on construction which never can be represented adequately by the bare bones of an inventory.

There are many engineers who might profitably give more attention to the subject of overhead charges, including such items as preliminary expenses, legal and other organization expenses, engineering, superintendence, contractor's expense, interest and taxes during construction, liability and other insurance, omissions and contingencies, etc.; and it might be well, even if the engineer does not assume the responsibility for the expense of financing, for him to remember that this is frequently a heavy item of cost. In other words, if the engineer's estimate is not inclusive and final, he should recognize that fact and place it on the record. Engineers have been responsible for much misapprehension because of their failures in this respect.

But we have only seen so far what it is costing the government to do this unnecessary work, the *ultimate purpose of which has not been decided even by the commission.*

It was originally estimated that it would cost the railroads of the United States to complete their work on the valuations $6 000 000. It is now seen that this is far below the probable cost, and an estimate recently made is $50 000 000. I believe that the direct and indirect cost will exceed this last amount.

The railroads, through their joint committees, are loyally coöperating with the commission in this work, but naturally they would be encouraged if they knew how these data, accumulated at such vast cost and inconvenience, are to be made to serve a useful purpose. I believe it can safely be asserted that the commission is not as yet able to inform the railroads, and this for the reason that they, themselves, do not know.

Since writing this address, it has been my privilege to read a paper entitled, "The Federal Valuation of Railroads," by Morrell W. Gaines, of Brown Bros. & Company, reprinted from the *Yale Review*, April, 1916. I quote the two first paragraphs of Mr. Gaines' admirable paper, in the hope that many of those present may thus be induced to read it in its entirety:

"Railroad control by governmental commissions is properly a means and not an end. It glitters with technique and is refulgent of policies. But it tends to become its own object and to spend itself in a futile perfecting of administrative machinery. This has become more plainly evident since the war, by its vast consumption of capital, has made possible the goal of an ultimate re-financing, through which the stocks and bonds of the railroad companies should be transferred to the shoulders of the government. Of the mechanism that the commissions have conceived, the valuation of the railroads by the Interstate Commerce Commission is the most recent and most gigantic enlargement — the most searching in attack on the joints of the armor of private ownership. Viewed critically, it is but an uninspired assembling of barren facts, crude in its disregard both of practical results and of plain principles of ethics. Nevertheless, it is an approaching reality and will have consequences that must be reckoned with.

"Private ownership of railroads has become public investment in their securities. There are 622 000 stockholders. Directly and indirectly, there are some tens of millions of bondholders. The 11 000 000 deposit accounts in savings banks and the 40 000 000 life insurance policies derive both income and safety from railroad investment. The nation itself, in its individual capacity, already owns the outstanding sixteen billion dollars par of railroad securities. The owners and creditors of the railroads are not, therefore, a group or class; they are the people of the United States."

There are many items in addition to overhead charges on which the commission and the railroads will find it difficult to agree. One of these is so-called depreciation — the estimated cost of the renewals of plant to be made in regular course. Unless the annual charges for plant maintenance are so distributed over a wide area and for plant units of such varying age as to make the annual expenditures fairly near the annual average total accrued cost of renewals, a reserve should be set up to cover this accrued liability. This reserve, which is intended, or should be intended, only to spread the cost of renewals uniformly over the years of service, does not represent real depreciation of plant. The use of the term " depreciation " in this connection is misleading. Under this theory the plant is still working effectively, efficiently and economically; otherwise it should sooner be renewed or replaced than is indicated in the estimate of expected life. The plant is guaranteed by the owning and operating company and is performing full service. This liability for subsequent renewals, which is so erroneously called " depreciation," is not the reduction in worth or value as viewed by a possible purchaser, but it is the accrued liability of the owner for the renewal of all parts as these parts become uneconomical, inefficient or inadequate.

As long as a public service property does not change hands, the corporation is obliged to make all necessary renewals; and if the property does change hands, the new owner has to assume this obligation. This is not a case where the capital in plant is to be amortized, but it is the case of a plant continued indefinitely in operation to meet the demands of the public.

To deduct from the value of plant on account of the accruing or accrued cost of renewals, if that deduction is enforced as influencing the rates for service or in any other way, *the plant in the meantime being maintained thoroughly*, means, necessarily, confiscation.

Thus far I have referred only to the Interstate Commerce Commission in connection with the railroads. But the railroads have the state commissions also to deal with. And here, not infrequently, they are called upon to obey orders from one commission which conflict with orders from another commission. Just by way of a suggestion, let me quote from an address by Alfred P. Thom before the State Bar Association of Tennessee:

" Three states have passed laws making it illegal for a carrier having repair shops in the state to send any of its equipment, which it is possible to repair there, out of the state for repairs in another state; fifteen states have attempted to secure preferred treatment of their state traffic, either by heavy penalties for delays or by prescribing a minimum movement of freight cars, some of them requiring a minimum movement of fifty miles per day, whereas the average movement for the United States is not more than twenty-six miles per day,— one of these states imposing a fine of ten dollars per hour for the forbidden delay; twenty states have hours-of-service laws, varying from ten to sixteen hours; twenty states have full-crew laws; twenty-eight states have headlight laws, with varying requirements as to the character of the lights, and fourteen states have safety-appliance acts. Sixteen states have enacted statutes, each asserting for itself the individual right to control the issue of stocks and bonds of interstate carriers.

"It is manifest, that if such issue is to be regulated by the individual states, every state is at the mercy of the others. A bond, to be available in the market, must, as a rule — especially now when most bonds are necessarily junior liens — be secured upon the whole railroad line; and this crosses many states. One of the states, therefore, if it possesses the power to regulate the issue of securities of an interstate carrier, may defeat a financial plan approved by all the other states and necessary to the carrier's transportation efficiency. . . .

"In other words, the greediest, the most selfish and the most unreasonable state thus secures by its own laws a preference for its own commerce over the commerce of its sister states and over interstate commerce itself."

I attach as an appendix to this paper a letter from Mr. Stuyvesant Fish, published in the New York *Sun* of March 23, 1916, which is significant and enlightening in connection with this multiplication of agencies of regulations and the necessary evils thus developed.

Referring now to the state commissions, for I have had little personal experience with the Interstate Commerce Commission, it is particularly unfortunate that the hearings are so often conducted in a manner to bring discredit on the system. Even if there were no other reason for criticism, this would be a sufficient condemnation.

Frequently the presiding commissioner examines witnesses in a way to indicate partisanship and bias. Witnesses are so examined as to cloud and confuse rather than to clarify the record. The commissioner presiding should so examine witnesses as to make clear that which has been left obscure. Especially in the case of stupid or timid witnesses, he should consider it a privilege to develop the truth, the whole truth and nothing but the truth. While these incompetent witnesses should be assisted, the tricky witness should be relentlessly cross-examined.

I have listened to commissioners examining most sympathetically witnesses who were testifying for the complainants and against the public service corporation, and then examining witnesses for the corporation in a manner diametrically opposite. I could give instances of such unfairness and arbitrary power which the uninformed would find it hard to believe. I was concerned in a case where the presiding commissioner stated in his opinion that on a certain most important feature, no direct evidence had been offered, whereas the evidence given was far more complete than in any other case within my knowledge. In fact, the evidence included the record, made up from the evidence of four witnesses, of a physical examination extending over days and carried through in great detail, twelve persons participating, representing the city, the commission and the public service corporation. In this same opinion the chairman laid the burden for a change in the keeping of the accounts upon the corporation, and imputed wrong motives in that connection, whereas the change had been made by the commission against the repeated protests of the company's president. Also in the same opinion, this chairman ascribed to a witness for the company evidence given in a previous case by a witness for the city who had, on cross-examination, been completely discredited. He then proceeded to compare this testimony with testimony on the same subject by a witness for the company in the present case, and, having shown the wide variations, proceeded to express the opinion that the testimony was valueless and that all engineers' testimony had to be received with great caution if not thrown out altogether.

I was concerned in a case where an expert for the city was allowed to testify with respect to many cities in the United States, Canada and Europe, but when the corporation's witness went on the stand to refute the testimony, he was at once confined to testifying with respect to the city directly concerned. In this case the chairman of the commission (all members of the commission were sitting) refused to strike out the testimony of the city's expert with respect to the many other cities the complainant's witness had covered in his testimony, saying that he had changed his mind since he had permitted the city's witness such latitude, but he would keep the testimony on the record, as it might prove to be helpful. Fortunately such rank abuse of authority as this cannot pass a decent court on appeal. The trouble here is that many cases which should be carried to the courts are not appealed for reasons of policy, timidity or general lack of backbone. By experience, I am convinced that the corporations have suffered material loss and loss of prestige by this cowardly course. Unless the corporations fight for their just due, they are charged with being found in the wrong. They should be very sure they are right, and then fight to the limit.

While, of course, I have been concerned in cases before these commissions where the hearings were conducted fairly and decently, I am obliged to say that these cases have not, in my personal experience, been in the majority.

While the system of regulation needs to be reformed for the reason that it is fundamentally in conflict with our form of government, one improvement can be made as to the operation of the system. I have for years been making this suggestion. Now that it has come to pass that Judge Prouty and Commissioner Daniels of the Interstate Commerce Commission have made the same suggestion, we may hope that this opportunity for improvement may more often be accepted.

I believe that many of the minor troubles and the injustices could be eliminated from commission control if thoroughly qualified engineers were put on the boards. Many, almost all, of the questions which come before our commissions require for their solution the highest engineering training and experience. I hold, therefore, that every commission should have at least one engineer as a member. I do not for a moment contend that a man is qualified for this tremendously responsible and important office simply by reason of his being an engineer, any more than I believe that a man is qualified to be a competent and upright judge because he has been admitted to the bar. An engineer to be qualified for this position of grave responsibility should be a man of high character, of sound training in theory and practice, and of wide experience in design, construction and administration. In general, all of our public service commissioners should be broadly trained, broad-minded, fair and competent as investigators (an unusual qualification); and in each commission there should be men fully qualified in the theory and practice of the professions of engineering, law, business, finance and accountancy.

The question then is, How shall we get enough of such men in view of the small inducements offered and the political pressure to which they are submitted? I confess I am unable to suggest a solution of this momentous problem.

I come back now to the proposition that in a democracy we must be prepared to pay a price for the liberties enjoyed under that form of government, but it should be our constant endeavor to reduce the price and so maintain it at the lowest possible figure. To this end we should keep in mind the difference between a false democracy and a true democracy. And here I venture to repeat President Butler's statement of the difference:

> "Jealousy of power honestly gained and justly exercised, envy of attainments or possession, are characteristics of the mob, not of the people; of a democracy which is false, not of a democracy which is true. False democracy shouts, Every man down to the level of the average. True democracy cries, All men up to the heights of their fullest capacity for service and achievement. The two sides are everlastingly at war. The future of this nation, as the future of the world, is bound up with the hope of a true democracy that builds itself on liberty."

Thomas Jefferson, the third President of the United States, is credited with being the "most conspicuous apostle of democracy in America." I venture to repeat his warning also: "Agriculture, manufactures, commerce and navigation, the four pillars of our prosperity, are most thriving when left free to individual enterprise."

But in a government "of the people, by the people and for the people" we can do no less than expect that there shall be many suggestions looking to change in the details of government, and naturally the most vociferous voices will be heard and they will be those of the enthusiasts, probably uninformed, or misinformed, or both, and those of the demagogue and reformer who looks for the opportunity for personal advantage or profit in the turmoil of change. We are constantly reminded that the "Voice of the People" should control. It is not the *voice* of the people as represented by those most ready to voice their opinions, but the sober second thoughts of the informed people which should guide us in all propositions looking to change in law and government. And here it is well for us to bear in mind that those who appreciate their responsibility the most are those who think first and speak last. Unfortunately the politicians with their ears to the ground hear and heed the vociferous voice, for they recognize that is the voice heard at election time.

When we are troubled with the activities of the selfish or vicious reformer, we are reminded of Lavater's dictum: "He who reforms himself does most to reform the public."

And when we are troubled with the activities of the uninformed or misinformed enthusiasts, we do well to keep in mind two quotations which help us to understand the condition of mind of these perhaps honest people, and which I venture to repeat. From the New York *Sun:* "A psychological affliction that clothes hopes in the raiment of fact and translates altruistic ambitions into accomplished ends." And from Dr. Henry S. Pritchett: "The world is full of devotion; but the devotion which thinks clearly, which has a true perspective, which can reckon with time, is rare."

True progress, true reform, is evolutionary, not revolutionary. Our reform, and particularly of late years, has been decidedly revolutionary, and so the price we pay for our democracy in the form of inefficiency and uneven application of law is increased rather than decreased. The people as a whole, through their representatives, should direct only as to principles and larger policies; the individuals should be left free to work out their own salvation with respect to the things less essential. And this principle should again be enforced in differentiating between the questions which affect the nation as a whole and the things which affect separate communities. While there should be a firm and binding national policy, simple and uninvolved as is possible, there should be beyond that the greatest possible freedom as to home rule with respect to the separate communities.

Those of us who have had the opportunities to compare the fruits of individual enterprise with those of government ownership and management — and we have all had such opportunities, though we may not have intelligently and honestly availed ourselves of these opportunities — must acknowledge that a privately owned and conducted enterprise could not live if it had to carry the burdens of political favoritism and interference which go with government enterprises. And this is what all of our commercial and industrial enterprises are coming to unless the voters do some hard thinking for themselves and learn to despise the empty oratory of the mere vote seeker.

The fact is not sufficiently kept in mind even by the engineers themselves that engineering in one way or another permeates nearly every activity of our daily life.

Therefore, the engineers, by their book and laboratory education and their subsequent education in the school of experience, should be peculiarly qualified to analyze the questions presented to the public, and particularly those questions which are presented under a cloud of inconsequential rhetoric.

All this means that a peculiar responsibility rests upon the members of the engineering profession with respect to the duties of citizenship. No longer should we permit the lawyers and economists to make our laws and say how, when, and where they are to be enforced.

## APPENDIX.

### RAILROAD REGULATION.*

Mr. Stuyvesant Fish Urges Full Exercise of Congressional Powers.

To the Editor of The Sun:

*Sir*, — The editorial article of March 5 on "Federal Charters for Railroads," the letter by "Civitas" therein referred to, his later letter published March 14 and the one signed "Lex" in *The Sun* of March 16, all favor the enactment by Congress of laws for the incorporation of railroads.

*The Sun* and its correspondents are right in believing that neither the

* From the New York *Sun*, March 23, 1916.

railroads nor the people served by them can longer endure the economic waste arising from the regulation of our commercial highways, railroads, by the Federal Government, by some forty-odd state commissions and by municipalities.

But will the granting of Federal charters bring the regulation of railroads under one single control? Many strong railroad corporations enjoy invaluable rights under their state charters, such as perpetual succession, exemptions from or peculiar provisions in respect to taxation, powers to cross and divert waterways and highways, to condemn needed lands and to make by-laws for the conduct of their business. Such contractual rights directors cannot, in justice to their stockholders, relinquish. However attractive Federal charters may seem to bankrupt railroads in process of reorganization and to the promoters of new ones, it is not to be expected that the strong companies will avail of them. Especially is this true of those which, by paying dividends for many years, have established in their present corporate names a credit known all over the world. The enactment of Federal laws for the incorporation of railroads will therefore tend to complicate further the situation by creating a new class of corporations, without getting wholly rid of the two existing classes created by individual states and by groups of states respectively.

The Constitution of the United States as adopted in 1787 and now in force gives to Congress power "to regulate commerce with foreign nations, and among the several states, and with the Indian tribes."

The powers thus granted in respect to commerce with foreign nations and with the Indian tribes were availed of at once. The advent of steamboats was at an early day followed by legislation for the regulation of all of them, everywhere.

Congress, having in 1823 enacted "that all waters on which steamboats regularly pass from port to port shall be considered and established as post roads" (Statutes at Large, III, page 767, being Section 3 of Chapter 33), in 1838 further enacted "that each and every railroad within the limits of the United States which now is or hereafter may be made and completed, shall be a post route" (Statutes at Large, V, page 283, being Section 2 of Chapter 172). There were then few if any railroads crossing state boundaries. In the whole country there were but 1 843 miles of railroad.

At that time, July 7, 1838, President Van Buren also approved another act for the better security of passengers on steamboats. (Statutes at Large, V, page 304, being Chapter 191.) This required "all owners of steamboats," without exception, to take out a new license thereunder, and made it unlawful to transport goods or passengers without such license. That act called for the periodic inspection of boilers, machinery and hulls; required the employment of a competent number of skilled engineers; that the safety valve shall be opened whenever a vessel is stopped; that every steamboat running between sunset and sunrise shall carry signal lights visible to other boats; that every person employed on board any steamboat by whose misconduct, negligence or inattention to duty the life of any person on board may be destroyed shall be guilty of manslaughter and on conviction sentenced to confinement at hard labor for not more than ten years; that in all suits against owners of steamboats for injuries arising to person or property from the bursting of the boiler, or the collapse of a flue, or other injurious escape of steam, the fact of such bursting, collapse or injurious escape of steam shall be taken as full prima facie evidence, sufficient to charge the defendant, or those in his employ, with negligence.

In 1852 an exception was made as to steam ferry boats and canal boats. But at present, and since at least 1871, all vessels and boats propelled in whole or in part by steam, navigating any waters "which are common highways of commerce," are under Federal regulation, with the single exception of canal boats. (Revised Statutes, Title III, Chapter 1, Sections 4399, 4400.)

Although most of our great railroad systems, substantially as they exist to-day, had been organized under state laws long before 1887, it was not until then that Congress began to legislate concerning their regulation, and in so doing it has as yet availed of but a part of its constitutional powers over them. The initial paragraph of that which has come to be called the interstate commerce law, but is entitled "An Act to regulate commerce," approved February 4, 1887, limits the application of the law, in so far as it relates to "commerce among the several states," to common carriers engaged in transportation "from one state or territory of the United States, or the District of Columbia, to any other state or territory of the United States, or the District of Columbia," and ends as follows:

"Provided, however, that the provisions of this act shall not apply to the transportation of passengers or property, or to the receiving, delivering, storage or handling of property, wholly within one state, and not shipped to or from a foreign country from or to any state or territory as aforesaid."

Had that law been made to apply, without limit, to all carriers by rail engaged in "commerce among the several states," such commerce would long before this have been freed of conflicting Federal, State and municipal regulations.

The time has now come when Congress must either avail of its power to regulate commerce by rail in its entirety, that is, wherever such commerce exists and in respect to whatever it consists of, "among the several states," or confess failure and abandon the attempts thus far made to regulate only so much thereof as passes from one state to another. Neither the railroad corporations, nor the merchants engaged in commerce, nor the ultimate consumers, who finally pay the cost, can longer endure the uneconomic chaos in which the actions of forty-eight mutually jealous states have involved and are further involving such commerce.

As long ago as in the Mississippi Railroad Commission cases (Stone *v.* Farmers Loan and Trust Co., et cetera, 116 U. S.), heard by the Supreme Court in 1885 and decided in January, 1886, the late James Fentress argued on behalf of the Illinois Central Railroad Company for the all-embracing nature of the power of Congress over commerce by railroad. I have been unable to find a copy of his brief, but well remember that among other things it showed that the word "among" means "in the midst of," that it cannot be applied to two but only to larger numbers, while "between" must of necessity refer solely to two; and further that the use in the commerce clause of the words "the several" to qualify "states" absolutely precludes such a narrow meaning as that the power of Congress is limited to the regulation of commerce between two states or two groups of states. The cases last above referred to involved other issues, and the court did not see fit to rule on the particular point thus raised by Judge Fentress. The court did, however, say, "Nothing can be done by the Government of Mississippi which will operate as a burden on the interstate business of the company."

I am not unmindful of the fact that decisions of the Supreme Court have been cited to show that Congress has no power over railroads in respect to such of their business as has both origin and destination in the same state, but let me ask, How far have those citations become available to that end by reason of the non-action of Congress from the inception of railroads in 1830 down to 1887, and by its then exercising but a part of its power to regulate railroads? I have always believed and often publicly said that when Congress shall legislate in respect to railroads in the precise language of its constitutional power to regulate "commerce among the several states," without making any exception, the court will sustain the constitutionality of the act.

The evils under which our whole people suffer are commercial and national, and their removal calls for the exercise by Congress in respect to railroads of all its powers over commerce. Except in the matter of rates charged, Congress has for eighty years most minutely regulated all steam carriers by water. It is high time that it should regulate all carriers by rail, and do it everywhere, "among the several states."

STUYVESANT FISH.

NEW YORK, March 22.

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PAPERS AND DISCUSSIONS

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# DISCUSSION OF POWER ESTIMATES FROM STREAM FLOW AND RAINFALL DATA.

By Messrs. Allen Hazen, Clemens Herschel, E. F. Chandler, C. H. Pierce, E. S. Glines, H. K. Barrows and Dana M. Wood.

Mr. Hazen* (*by letter*). — The writer is glad to see that the distinction between computations from monthly averages, from weekly averages and daily records is made. It might be made even more emphatic with advantage. Monthly averages are convenient. Sometimes the daily flows are not available, but where storage is not at hand to balance the irregularities of flow during each month, the error that may result in computations based upon monthly figures is quite large.

This is illustrated by Table 1, which shows the percentages of time that flows of given sizes are apparently available for two streams; namely, the Manhan River and the Susquehanna River; first, on the basis of the daily records; second, on the basis of the monthly records.

The figures obtained from the daily records are substantially exact, and the differences show the errors reached in using the monthly figures. In all cases, the monthly figures give much higher results, and if a plant is built on the basis of computations based on them, the operating results will be disappointing.

*Of Hazen, Whipple & Fuller, Consulting Engineers, New York.

TABLE 1.

ERROR MADE BY USING MONTHLY AVERAGE FIGURES.

| Flow as Per Cent. of Mean Flow. | Manhan. Per Cent. of Time that Full Flow is Available. Daily Records. | Manhan. Per Cent. of Time that Full Flow is Available. Monthly Records. | Susquehanna. Per Cent. of Time that Full Flow is Available. Daily Records. | Susquehanna. Per Cent. of Time that Full Flow is Available. Monthly Records. |
|---|---|---|---|---|
| 0.3 | 65 | 69 | 75 | 81 |
| 0.5 | 48 | 63 | 56 | 64 |
| 0.7 | 37 | 51 | 44 | 53 |
| 1.0 | 27 | 37 | 31 | 40 |
| 1.5 | 17 | 23 | 20 | 24 |

The writer also wishes to suggest that, rather than take second-feet per square mile as a basis for the calculations, it will often facilitate comparisons to use instead as a basis the mean flow. In this case, all the rates that are discussed are referred to as percentages of the mean flow. This was done in Table 1. The mean flow of a stream for a term of years is usually either known or is estimated as a starting point. The wheel capacities are then stated in terms of the mean annual flow. Comparisons between data for different streams arranged in this way indicate less variation between different streams than where second-feet per square mile is taken as a starting point.

To illustrate, Table 2 shows the characteristics of flow of three streams. The wheel capacity is shown as a percentage of the mean flow. There is next shown the percentage of the whole time when wheels can be operated at capacity without storage; that is to say, the percentage of the time when the flow of the stream is greater than the amount in the same line of the first column. There is next shown the summation of all the flows smaller than the assumed limit, the amounts of the summation being expressed as a percentage of the total annual flow; and finally there is shown the total flow that can be utilized, which is made up of the whole of the sum of the flows less than the limit, and the amount that can be utilized of the flows above the limit, which is practically the wheel capacity for that portion of the time for which the flow exceeds the limit. For example, for the Connecticut River, with a wheel capacity equal to 60 per cent. of the mean flow, the flow is in excess of the limit for 50 per cent. of the time, and during this 50 per cent. of the time the total flow utilized would be 60 per cent. of 50 per cent. or 30 per cent. of the whole flow. During the 50 per cent. of the time when the flow is less than the limit, the whole amount of flow or 18 per cent. of the whole annual flow can be used, and, adding this to the 30 per cent., it is found that 48 per cent. of the total flow (as shown in the table) can be utilized with this amount of wheel capacity.

TABLE 2.

| Wheel Capacity as Per Cent. of Mean Flow. | Per Cent. of Whole Time at Which Wheels can be Operated at Capacity. | | | Percentage of Total Flow during Days when Less than Full Capacity Flows. | | | Percentage of Total Flow that can be Utilized by Wheels. | | |
|---|---|---|---|---|---|---|---|---|---|
| | C. | S. | M. | C. | S. | M. | C. | S. | M. |
| 10 | 100 | 97 | 92 | 0 | 0.3 | 0.6 | 10 | 10 | 10 |
| 20 | 95 | 86 | 77 | 1 | 2 | 3 | 20 | 20 | 18 |
| 30 | 79 | 75 | 65 | 5 | 5 | 5 | 28 | 27 | 25 |
| 40 | 67 | 65 | 56 | 9 | 8 | 9 | 36 | 34 | 30 |
| 50 | 57 | 56 | 48 | 14 | 12 | 12 | 42 | 40 | 36 |
| 60 | 50 | 49 | 42 | 18 | 16 | 15 | 48 | 45 | 40 |
| 70 | 44 | 44 | 37 | 22 | 20 | 19 | 53 | 50 | 44 |
| 80 | 39 | 39 | 33 | 26 | 23 | 22 | 57 | 54 | 48 |
| 90 | 34 | 35 | 30 | 30 | 27 | 25 | 60 | 58 | 52 |
| 100 | 30 | 31 | 27 | 33 | 30 | 28 | 64 | 61 | 55 |
| 120 | 24 | 26 | 22 | 40 | 36 | 33 | 69 | 67 | 60 |
| 150 | 17 | 20 | 17 | 48 | 44 | 40 | 76 | 74 | 65 |
| 200 | 12 | 13 | 12 | 60 | 57 | 49 | 83 | 82 | 72 |
| 300 | 5 | 6 | 7 | 75 | 74 | 61 | 91 | 90 | 81 |

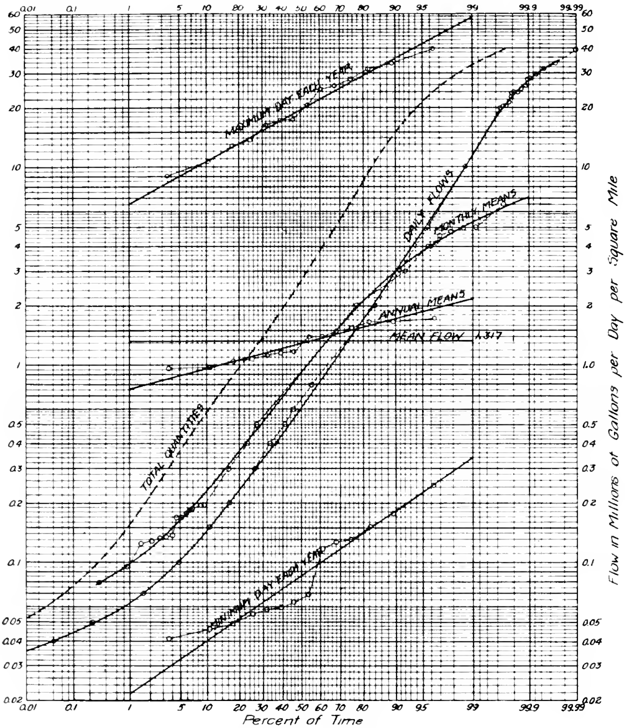
C = Connecticut River, Holyoke, Mass., 8 660 sq. mi., by ten-day periods for twenty years from 1880 to 1899. Clemens Herschel, Trans. Am. Soc. C. E., LVIII, 29.

S = Susquehanna River, Harrisburg, 23 885 sq. mi., daily records for twenty-two years, 1901–1912 inclusive; reports from the Penna. Water Supply Commission, Farley Gannett, engineer.

M = Manhan River, of Holyoke, Mass., Water Works, 13 sq. mi., daily records for fourteen years, 1897–1910 inclusive; weir gagings by James L. Tighe, city engineer.

This table also shows the amount of water that can be diverted by a canal or aqueduct of a given capacity.

The three streams shown in this table have very great differences in size, character of watershed, and amount and rate




MANHAN RIVER
HOLYOKE WATER WORKS
14 YEARS 1897-1910
AREA 13 SQ MI

FIG. 1.

of run-off, but the figures reached by this method of comparison show only a moderate range and will serve as a basis for many estimates with a fair degree of probable accuracy.

These figures were obtained from the original records by arranging the figures in groups according to magnitude and plotting them on logarithmic probability paper, following the general methods used in the paper presented by the writer to the American Society of Civil Engineers, Vol. LXVIII, page 1539. One of the diagrams made, representing the flow characteristics of the Manhan River, and which shows not only the data used in this discussion but also the flood flows, the minimum flows and the annual means, is presented herewith. (Fig. 1.)

## Rainfall Records and Run-Off.

Mr. Herschel* (*by letter*).—Some seventy years ago, about the time when the Croton and the Cochituate (the first New York and the first Boston) gravity water works were built, their engineers began to publish rainfall observations, and began to make the attempt to deduce from them for future prognostications annual and monthly yields of rainfall, or of river run-off, to use the modern term. And that sort of striving to compute the incomputable has continued down to the present day. The term "incomputable" has been used advisedly, because no direct relation between annual, monthly or any other period of rainfall and the run-off during the same period of time has ever yet been discovered, nor ever will be. It was soon seen that in some months more water ran off than fell, even in New England with only about 50 per cent. average annual net yield of rainfall, but varying between wide limits of annual percentage. In England, where the annual yield is some 75 per cent. of the rainfall, this excess of yield over the producing cause occurred in sixty-four months out of three hundred and twenty-four months observed, varying from six such months in one year to no such month in a year; or, in another case, in sixteen months out of eighty-four months of observation, varying from three months in a year to one such month in a year.† Such yield varies also according to the distribution of the rainfall throughout the year — whether in small rainfalls at short intervals, or

* Civil and Hydraulic Engineer, New York.

† Min. Proc. Inst. C. E., 1912–1913, Pt. 4, p. 94.

whether the same total amount falls in one or a few showers. So that years of the same rainfall yield very different run-offs; and less total rainfall will often yield a greater run-off; and vice versa.

Then, again, what *is* the rainfall on any given watershed? Rain gages are set up at considerable distances apart, and by no means can measure the rainfall on any given contiguous number of square miles. But, apart from such considerations, why, when seeking run-off, should engineers turn their backs upon it, and go off poring over records of rainfall, and endeavor, by dint of much tribulation, to compute a relation between it and rainfall? That sort of thing was well enough in the 40's of the nineteenth century, when it was started, but to-day it is surely time that it be recognized as a false method of work, and engineers' energies should be concentrated on stream measurements and a comparison of such, when the future yield of drainage areas is in question.

It is submitted that by such comparisons or analogies much more reliable results in the line of yield prognostications can to-day be obtained, when direct gagings are lacking, than rainfall studies, and computations based upon them, can ever furnish.

In short, it is time to put away childish things; and among such, in hydrological studies, it is clear, may be counted the numberless attempts that have been made in years past to compute from past rainfall observations the to-be-expected maximum, minimum or average annual, monthly, weekly or daily yields. To attempt to do so, even only to recite past or suggested methods of doing so, distracts from the pursuit of the much more promising lead furnished by the study of such run-off gagings as are already on record; and, in the opinion of the writer, is to be discouraged as a distraction, and as hindering an extension of run-off gagings and of results to be found from their study; as making for blindness or the obscuring of vision and for arresting progress.

## Run-Off Diagrams.

Having given a record of run-off gagings, how shall they be arranged for the use of the hydraulic engineer?

Now, confining ourselves to the considerations uppermost in the mind of the engineer of water *power* (not water supply), it has long been clear to the writer that there must be one best way; also that in the interests of efficient work and of an avoidance of wasted effort, this best way should be followed, rather than pursue the study of many such ways.

A mine of information on stream flows is contained in the reports of the U. S. Geological Survey on that subject, which have now attained nigh four hundred unbound volumes, some of them quite bulky, making a burden on the resources of engineers who pay the rent of their own offices and shelf-room. It is no exaggeration to say that for water-power purposes, giving all data needed for that purpose, these four hundred bulky reports could be condensed into four hundred single-page cuts contained in one such volume, and at an enormous saving to the work, time and expenses of the hydraulic engineer.

For the purpose of facilitating comparison and reducing all the records to the same specific scale as it were, the collected diagrams should be plotted to represent second-feet per square mile, instead of second-feet. Underlying details would not be lost, but if ever needed (a matter of some doubt) could be supplied by the Survey Office. In answer to an inquiry requesting suggestions, the writer had the honor to make the above recommendations to the Geological Survey office and here reiterates this his maturėd opinion on the subject.

If the daily discharges of a river at a certain point be plotted for the three hundred and sixty-five days of the year, *in the order of their magnitude* (not consecutively in the order of the date of their occurrence), a perfectly smooth curve showing the year's discharge will be produced. Take fifteen or twenty such years, if the records avail, and three such curves may be produced; one of average flow, another enveloping all the minima flows, and a third enveloping the maxima flows. And for a period of that length the discharge of that river, at that point, has been portrayed practically for all time. Nothing, or little more, is needed in its hydrographic study, for the uses of a constructing engineer. Its original data may have interest for a meteorologist, when he philosophizes as to the relation between such three curves and rainfall data, but an engineer has nothing to do with that. The rainfall may be anything; it will not change the recorded run-off, nor the ranges of run-off shown by these three curves. And it is these data that are needed for useful purposes, — the province of the engineer, — in contradistinction to the pastures of recreation that invite the philosopher or scientist. The same data may also be presented, if preferred, in tabular form; would have to be, before they can be " boiled down " into the diagram which has been described. Such tables are presented in Trans. Am. Soc. C. E., 1907, p. 29, " Twenty Years' Run-off, at Holyoke, Massachusetts, of the Connecticut River "; and in H. R. Doc. 1400, 62d Congress, 3d Session, 1913, Fifteen Years' Run-off of the Potomac River, at Great Falls, near Washington, D. C.; while such diagrams are shown in *Engineering News*, September 4, 1913; H. R. Doc. 1400, above referred to, Plate 37; and Min. Proc. Inst. C. E., Session 1912–1913, Part 4, p. 95.

It has already been explained that in cases where such long records, or any such, do not exist, recourse must be had to reasoning from analogy; something that is not unknown when yield by means of rainfall computations is striven for. Having regard to location, upland or lowland, mountainous or flat land, size and shape of drainage area, area of pond or lake surfaces in it, and climate, it is the writer's firm belief that, by reasoning to-day from analogous cases of stream flow, better results will be attained than computations based on rainfall records can ever produce.

As an example of the tables and diagrams spoken of, one of each is here reproduced; the table, from the paper on twenty years' run-off of the Connecticut River; the diagram, from Doc. 1400 referred to.

The bold-face figures in the table, showing maximum and minimum in each horizontal line, give the data for the enveloping curves that have been spoken of. The two full lines extending

TABLE 3. — TWENTY YEARS' FLOW OF THE CONNECTICUT RIVER AT HOLYOKE, MASS.

Figures represent Second-Feet in Twenty-four Hours.

| Day. | 1880. | 1881. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. | 1888. | 1889. | 1890. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | 1898. | 1899. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 44 100 | 49 050 | 43 650 | 68 300 | 71 900 | 63 950 | 80 150 | 85 500 | 99 750 | **37 800** | 46 750 | 67 300 | 63 100 | 94 350 | 43 300 | **115 000** | 112 050 | 75 350 | 76 150 | 82 500 |
| | **28 900** | 45 100 | 30 850 | 36 550 | 49 500 | 44 350 | 42 700 | 63 550 | 65 150 | 32 300 | 39 650 | 54 450 | 42 950 | 42 550 | 33 400 | 50 800 | 61 950 | 53 650 | 50 750 | **67 250** |
| | **22 900** | 32 850 | 25 900 | 25 200 | 37 950 | 36 650 | 36 600 | **50 150** | 49 850 | 29 050 | 36 550 | 43 000 | 31 700 | 36 950 | 26 550 | 33 550 | 37 300 | 44 200 | 41 550 | 45 900 |
| | 19 800 | 25 200 | 23 500 | 19 950 | 30 750 | 30 700 | 29 250 | 37 000 | **40 600** | 26 450 | 33 500 | 32 750 | 27 200 | 32 000 | **18 550** | 24 700 | 26 150 | 37 000 | 31 500 | 23 200 |
| | 17 550 | 20 100 | 22 150 | 16 550 | 27 700 | 25 950 | 25 450 | 27 600 | **34 600** | 24 800 | 30 050 | 28 800 | 23 500 | 28 200 | **16 050** | 21 950 | 23 150 | 32 950 | 25 850 | 17 700 |
| 50 | 15 250 | 17 800 | 20 800 | 15 200 | 26 200 | 22 550 | 19 750 | 22 900 | **31 700** | 23 200 | 28 200 | 24 350 | 20 800 | 23 450 | **15 100** | 18 850 | 20 100 | 28 300 | 22 800 | 15 400 |
| | 14 250 | 16 600 | 18 900 | **13 000** | 24 250 | 19 200 | 17 600 | 20 550 | **30 000** | 21 350 | 26 250 | 22 250 | 18 050 | 17 700 | 13 950 | 16 200 | 18 300 | 26 350 | 21 000 | 14 000 |
| | 11 750 | 15 100 | 16 850 | **10 450** | 22 000 | 16 950 | 14 700 | 18 650 | **26 350** | 20 500 | 24 600 | 20 250 | 17 150 | 15 100 | 13 000 | 13 550 | 17 150 | 24 500 | 19 200 | 12 300 |
| | 10 900 | 14 300 | 15 300 | **9 000** | 18 950 | 16 200 | 14 050 | 17 000 | **24 150** | 19 400 | 23 150 | 19 050 | 15 600 | 12 700 | 11 750 | 10 900 | 15 050 | 22 950 | 17 850 | 11 400 |
| | 10 050 | 12 000 | 14 500 | **8 250** | 15 550 | 14 150 | 12 500 | 15 250 | **21 850** | 18 500 | 21 700 | 17 850 | 14 550 | 11 250 | 10 000 | 9 600 | 13 900 | 20 350 | 16 250 | 10 450 |
| 100 | 8 900 | 11 750 | 13 500 | **7 600** | 13 150 | 13 250 | 12 100 | 14 200 | **20 200** | 17 450 | 19 650 | 16 600 | 13 800 | 9 950 | 8 800 | 9 050 | 12 800 | 19 200 | 15 150 | 9 950 |
| | 8 500 | 11 000 | 12 500 | **7 000** | 12 300 | 12 400 | 11 500 | 12 950 | **19 250** | 16 650 | 18 450 | 14 500 | 13 250 | 9 100 | 8 200 | 8 400 | 11 650 | 18 050 | 14 400 | 9 000 |
| | 8 300 | 10 050 | 11 600 | **6 550** | 11 100 | 11 550 | 10 900 | 12 300 | **18 250** | 16 100 | 17 750 | 13 700 | 12 600 | 8 500 | 7 800 | 7 750 | 10 700 | 16 800 | 13 750 | 8 150 |
| | 7 950 | 9 400 | 10 500 | **5 950** | 10 300 | 11 050 | 10 250 | 11 450 | **17 600** | 15 550 | 17 100 | 12 500 | 12 200 | 7 800 | 7 400 | 7 250 | 9 800 | 16 100 | 12 950 | 7 750 |
| | 7 500 | 8 850 | 9 250 | **5 150** | 9 250 | 10 550 | 9 800 | 10 750 | **16 700** | 14 650 | 16 050 | 11 350 | 11 600 | 7 300 | 6 950 | 6 300 | 9 300 | 15 300 | 12 450 | 7 200 |
| 150 | 7 300 | 7 900 | 8 350 | **4 850** | 8 750 | 9 200 | 9 600 | 10 150 | **15 600** | 14 250 | 14 950 | 10 500 | 11 100 | 6 850 | 6 550 | 6 050 | 8 550 | 13 950 | 12 000 | 6 600 |
| | 6 900 | 7 150 | 7 500 | **4 650** | 8 150 | 8 850 | 9 200 | 9 850 | 14 300 | 13 550 | **14 400** | 9 600 | 10 250 | 6 450 | 6 250 | 5 800 | 8 050 | 13 200 | 11 550 | 6 050 |
| | 6 350 | 6 650 | 6 950 | **4 400** | 7 550 | 8 300 | 8 850 | 9 500 | 13 500 | 12 800 | **13 700** | 8 800 | 9 500 | 6 050 | 5 950 | 5 200 | 7 700 | 12 650 | 10 700 | 5 650 |
| | 5 350 | 6 350 | 6 400 | **4 100** | 7 200 | 8 050 | 8 500 | 9 150 | 12 400 | 12 150 | **13 400** | 7 600 | 9 100 | 5 900 | 5 700 | 4 900 | 7 150 | 11 800 | 10 150 | 5 400 |
| | 4 600 | 5 500 | 5 750 | **3 900** | 6 700 | 7 800 | 8 100 | 8 850 | 11 400 | 11 650 | **12 800** | 7 200 | 8 600 | 5 650 | 5 450 | 4 750 | 6 850 | 10 550 | 9 700 | 5 350 |
| 200 | 4 000 | 5 200 | 5 050 | **3 750** | 5 950 | 7 650 | 7 800 | 8 500 | 10 600 | 11 250 | **12 050** | 6 650 | 8 150 | 5 200 | 5 200 | 1 550 | 6 500 | 10 200 | 9 200 | 5 250 |
| | 3 650 | 4 750 | 4 850 | **3 650** | 5 700 | 7 250 | 7 100 | 8 250 | 9 200 | 10 850 | **11 400** | 6 100 | 7 850 | 4 900 | 5 050 | 4 350 | 6 250 | 9 700 | 8 750 | 5 150 |
| | **3 500** | 4 200 | 4 400 | 3 600 | 5 600 | 6 800 | 7 050 | 7 900 | 8 500 | 10 500 | **10 500** | 6 000 | 7 500 | 4 750 | 4 950 | 4 100 | 6 050 | 9 150 | 8 450 | 5 000 |
| | **3 350** | 3 800 | 4 150 | 3 500 | 5 350 | 6 600 | 6 600 | 7 650 | 8 000 | 9 850 | **9 900** | 5 550 | 7 000 | 4 600 | 4 800 | 3 950 | 5 800 | 8 550 | 8 050 | 4 650 |
| | **3 200** | 3 700 | 3 800 | 3 450 | 5 100 | 6 250 | 6 000 | 7 550 | 7 650 | 9 500 | **9 600** | 5 250 | 6 600 | 4 450 | 4 750 | 3 800 | 5 250 | 8 000 | 7 700 | 4 500 |
| 250 | **3 000** | 3 600 | 3 700 | 3 400 | 4 900 | 5 900 | 4 900 | 7 350 | 7 300 | **9 150** | 9 000 | 5 100 | 6 400 | 4 350 | 4 650 | 3 600 | 4 900 | 6 500 | 7 550 | 4 150 |
| | **2 850** | 3 400 | 3 650 | 3 350 | 4 600 | 5 550 | 3 900 | 7 150 | 7 100 | **8 650** | 7 950 | 4 850 | 6 150 | 4 250 | 4 500 | 3 500 | 4 650 | 5 250 | 7 200 | 3 950 |
| | **2 350** | 3 100 | 3 550 | 3 250 | 4 350 | 5 450 | 3 450 | 6 600 | 7 000 | **8 000** | 7 250 | 4 600 | 5 000 | 4 050 | 4 250 | 3 400 | 4 500 | 5 000 | 6 700 | 3 550 |
| | **2 350** | 3 000 | 3 500 | 3 100 | 4 150 | 5 250 | 3 300 | 6 300 | 6 800 | **7 550** | 6 850 | 4 400 | 5 550 | 3 900 | 4 000 | 3 300 | 4 400 | 4 900 | 6 150 | 3 300 |
| | **2 150** | 2 050 | 3 450 | 2 950 | 4 000 | 5 000 | 3 200 | 6 150 | 6 500 | **7 250** | 6 300 | 4 150 | 5 150 | 3 850 | 3 600 | 3 150 | 4 300 | 4 700 | 5 850 | 3 200 |
| 300 | **2 150** | 2 950 | 3 250 | 2 900 | 3 700 | 4 850 | 3 150 | 5 750 | 6 300 | **7 000** | 5 950 | 4 050 | 4 950 | 3 750 | 3 350 | 3 150 | 4 150 | 4 450 | 5 050 | 3 050 |
| | **2 050** | 2 950 | 3 150 | 2 850 | 3 600 | 4 600 | 3 000 | 5 400 | 5 800 | **6 600** | 5 300 | 3 600 | 4 700 | 3 600 | 3 000 | 3 050 | 3 900 | 4 350 | 4 750 | 2 800 |
| | **2 050** | 2 950 | 3 000 | 2 750 | 3 500 | 4 300 | 2 800 | 4 600 | 5 350 | **6 250** | 4 800 | 3 500 | 4 500 | 3 350 | 2 750 | 3 000 | 3 750 | 3 900 | 4 400 | 2 700 |
| | **2 000** | 2 950 | 2 900 | 2 500 | 3 100 | 4 150 | 2 700 | 4 300 | 4 800 | **5 900** | 4 300 | 3 150 | 4 400 | 3 200 | 2 150 | 2 950 | 3 450 | 3 700 | 4 000 | 2 500 |
| | **1 950** | 2 950 | 2 850 | 2 300 | 2 950 | 3 850 | 2 500 | 4 150 | 3 700 | **4 650** | 3 700 | 2 950 | 4 300 | 3 050 | 2 350 | 2 900 | 2 850 | 3 550 | 3 600 | 2 400 |
| 350 | **1 750** | 2 850 | 2 500 | 2 150 | 2 700 | 3 550 | 2 350 | 3 750 | 3 450 | 3 650 | 3 550 | 2 900 | **4 150** | 2 800 | 1 900 | 2 850 | 2 700 | 3 350 | 3 450 | 2 350 |
| 365 | 1 650 | 2 700 | 2 400 | 1 950 | 2 650 | 3 050 | 2 100 | **3 650** | 3 000 | 3 100 | 2 750 | 2 750 | 3 000 | 2 550 | **1 600** | 2 700 | 2 100 | 3 000 | 3 200 | 2 250 |

across the table mark the limits between which the economical capacity for turbines to be installed will ordinarily be found, concerning which more is to follow. The data for the curve of average flow (averages of each horizontal line) have not been computed, but can be readily found from the table.

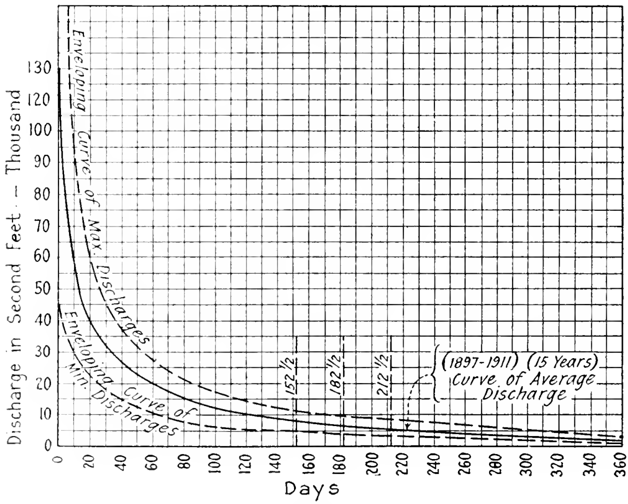



FIG. 2. CURVES PLOTTED FROM FIFTEEN YEARS' STREAM-FLOW RECORDS OF POTOMAC RIVER AT AQUEDUCT DAM, WASHINGTON, D. C.

The diagram will presumably need no explanation. It is the concise and true representation of the régime of the river, in this case the Potomac, near Washington, giving all data needed by a hydraulic power engineer. And, if we had such diagrams for the principal points on every river of importance in the United States, it would be the fulfillment of hydrographic study of river flow within the United States. A single volume containing such diagrams would then take the place of the several hundred volumes of undigested material relating to river flow which now obstruct useful work and the exercise of judgment; not to mention the lucubrations of rainfall recorders and of their obsequious followers.

## Warranted Turbine Capacity to be Installed.

In taking up this subject, let us assume that we speak here only of the ultimate development at any given mill-site. Power machinery may be installed at time intervals, as power is called for. Even the power house may be built in sections. Let us also recognize that while power dams and power houses are built to last forever and as a matter of fact naturally do endure on the average longer than most any other work an engineer is called upon to design and construct, yet the duration of such things as "load-factors" and given "peak loads" are in comparison but fading fancies. How, then, can they properly enter into a computation for power-house design in conjunction with factors that are eternal, or nearly so? The tendency of power-house management is constantly to strive for a load factor of one, and both the progress of invention and of sociology is working to that end. By the time a network of interconnected power wires, each arranged to convey a constant daily quantity of power, will have spread over all the thickly settled portions, or over the whole of the United States, farms included, which is rapidly being accomplished, where will the load factor and peak load be then? *

The state of electrical development just described is rapidly being accomplished in the Province of Ontario, Canada, as a state enterprise,† and there is nothing but notions of sociology to hinder its coming true in the United States by private enterprise.‡ Another consideration which this thought brings up is the one of variable power from day to day at any mill site; very present to those who are operating or have operated water power on most any stream except on those constituting the outflow of the Great Lakes; and the subject of permanent and surplus

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* *Electrical World*, March 11, 1916, p. 581.

† *Electrical World*, March 18, 1916.

‡ *Engineering Magazine*, February, 1916.

power; or, to use the later terms, of "primary" and "secondary" power.

Suppose we assume that there is no secondary power (there need not be); that it is all power that can be relied on to be at hand when called for. So far as the writer's judgment goes, based on ten years' experience in the administration of a water power, that is the only kind of power that should be offered for sale in the existing and the to-be-expected development of the business; in the interests of the seller, no less than in that of the buyer; and with the legitimate aid of heat engines and fall increasers to tide over low water and "back-water" troubles, and in spite of unavoidable annually recurring diminutions of power output, during nearly all the days of the year, there is no difficulty in attaining a uniformity of power output throughout every day of every year.

One might go further and prove that only by amalgamating heat engine and hydraulic power in this way can a full or complete return be gained from hydraulic power plant investments. All this was well understood full fifty years ago in New England manufacturing circles, if not elsewhere; but, with the advent of the electrical transmission of power, an army of ardent electricians, ill informed on hydraulic matters, were let loose upon an expectant country, and they had to learn all this over again. Some of them and their backers have not learnt it yet. We still hear of the minimum flow of the river on any one day in twenty years, as furnishing the measure of "primary" power, and there are great hydraulic power plants that needlessly waste over their dams, on more than half the days of an average year, a quantity of water which if properly utilized would generate 100 or 150 million kilowatt-hours annually, at a cost less than the fuel cost of the heat engines that must be installed to tide over *low-water* diminutions of normal power output.

Then there is the consideration of how much reservoir capacity or pondage is to be added to the power plant for the purpose of making the water supply more uniform, tending towards that happy era when there shall be no more times of low water and no more freshets.

A German writer has recently stated such a proposition as follows:

"Procedure for the Determination of the Most Economical *Part* of the Annual Run-off to be used; Size of Reservoir; and Amount of Auxiliary Heat Power which should be selected in the Construction of Water-Power Plants." *

As the learned author treats the subject, this includes a choice and determination: (*a*) Whether to use no water at all, or all the water that comes down the brook or river during the year; or what portion of the annual discharge of the stream is to be utilized; (*b*) whether to have no reservoirs, or reservoirs large enough to utilize the whole annual river flow; or what intermediary reservoir capacity is to be constructed; (*c*) whether to have water power only, or to use auxiliary heat engines; and, if any are to be used, to what extent; certainly a comprehensive program. And all this is to be answered strictly by computation, and results given by formulæ expressed in mathematical symbols! Does not this suggest the line: "Out of too much learning become mad?"

But let us analyze the task entered upon; (*a*) and (*b*) may be considered together, (*a*) being a function of (*b*). And economic reservoir capacity, to ordinary minds, is plainly a local consideration, to be answered in each case by the local situation, let the formulæ say what they will.

It is only very gradually that the mere idea of the applicability of the powers of eminent domain to the taking of land by condemnation for water-power purposes is being recognized in state constitutions and in court decisions, thence spreading to legislation (see a decision of the United States Supreme Court of January 24, 1916, in the case of the Alabama Interstate Power Co., opinion by Justice Holmes, as an important step forward in this direction); and without such right the opportunity of making use of computations relating to reservoir volumes would be somewhat doubtful. Then, again, are we to ignore topographical facilities or difficulties in such cases, in favor of the demands of general formulæ?

The writer believes that trial estimates will furnish a better

* Zeitschrift f. d. ges. Turbinenwesen, 1913, pp. 209, 230, 244.

guide in the vast majority of cases, very likely in all of them; and general experience has also indicated, at least as a beginning, to be modified if need be, by trial estimates in each case, how to answer division ($c$) of the problem as above stated.

This answer has already been indicated in the table of river flow above given, and may be stated as follows. The most economical discharge capacity of the turbines to be installed, so as fully to utilize the run-off at any mill site, is never very far either side on the diagram of the average river discharge on a day, than which there are as many days in the year of a greater as there are of a lesser river flow.

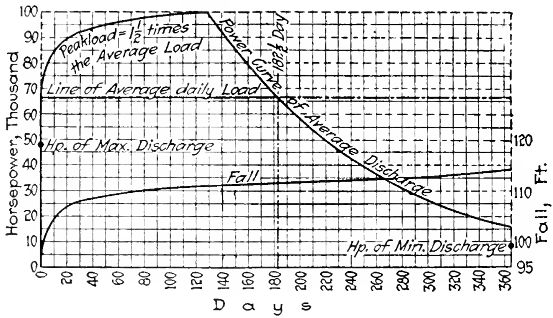


FIG. 3.

If, now, we have further the fall at the considered mill site appurtenant to the several river flows, fall also may be plotted as a curve; and from the two, quantity and fall, "Macaulay's schoolboy" could compute and plot the curve of resultant power for every day of an average year.

One factor more should, however, be taken into account: to accommodate peak loads or power variations occurring during the day, it is well to install wheels of a greater power capacity than has so far been indicated, running them normally at part gate. With all this entering into the computations, there will result the diagram given above, which presumably will need no explanation.

Auxiliary heat engine power, although its measure is indicated on the diagram, is not needed as a rule at first, except in process of developing the sale of power from the works, up to their full output capacity; and may thus be added gradually, as, indeed, may frequently, hydraulic turbine and even power-house capacity. All this makes for convenient elasticity in first installation, but will result, finally, in, what we have all along been aiming to attain, primarily or eventually, a full economical utilization of the natural resources of that power site.

MR. CHANDLER .(*by letter*).—In Mr. Wood's interesting paper on "Power Estimates from Stream Flow and Rainfall Data," I notice the warnings offered against the indiscriminate application of the rule presented by Mr. C. E. Grunsky and quoted on page 91, for estimating run-off as a percentage of rainfall, and desire to emphasize that warning. During thirteen years' experience as hydrographer for the U. S. Geological Survey in charge of all the river-record work in North Dakota and some adjoining regions, I have found every one of the percentage run-off formulas as ordinarily stated to be misleading and useless for this northern prairie region, and to give computed results three, four, or even ten times greater than the actual facts here, even though the formulas may apply approximately well for the regions in which they are developed.

Mr. Grunsky first stated his rule that, if the annual rainfall is less than 50 ins., the percentage of run-off may be expected to equal approximately the annual inches of rain, many years ago, and it should be noted that, in the May, 1915, issue of the Proceedings, Am. Soc. C. E., although he quotes it as a general rule that "will give fairly close results for practically any portion of the United States, " he also shows a curve applicable to the region with which he is himself most familiar (the Pacific slope), wherein the figures which the formula first stated would give are very much modified.

Similarly, now that the actual facts are available, very considerable modifications would need to be made in it to apply to the northern prairie region. In North Dakota, for example, with the long period average annual rainfall about 22 ins. at one side of the state and 14 ins. at the other, according to his rule as first stated, the expected run-off would be from 4.8 to 2.0 ins. Actually, for different streams in different years it varies from 3.0 to 0.2 ins., and the long-period averages for most of the streams are between 0.6 and 0.9 ins.

If, however, the figures as stated in Mr. Grunsky's original rule are suitably revised upon the basis of the actual records now available for this region, I believe that the principle upon which it is based, if the constants are properly selected empirically, gives the most convenient short method for rapid approximate estimates; namely, that if the annual rainfall exceeds some fixed constant $A$, all the precipitation in excess of some other constant $B$ (which is smaller than $A$) will appear in the run-off; if the rainfall is less than $A$, a variable percentage of it will appear in the run-off, such percentage being so related to the precipitation that the smaller the number of inches precipitation, the smaller the percentage.

Mr. Pierce * (*by letter*). — The subject of "Power Estimates from Stream Flow and Rainfall Data," covered by Mr. D. M. Wood in his paper, is so wide in its scope, and subject to so many variations for special conditions, that many more than the forty-two pages used by him would have been needed to cover all the details. As presented in his paper it is a treatise embodying a remarkably clear-cut exposition of methods actually used by hydraulic engineers who must make power estimates from the best data available, and who also must pass judgment on the reports of engineers, some of whom consistently make their reports unduly favorable while others may be inclined to reports that are generally unfavorable.

As preliminary to the design of water-power plants, especially those which are not likely to be supplemented by auxiliary steam power, emphasis should be placed on the need for accurate data regarding the actual daily flow of the stream. The records should, of course, be obtained as near the power site under consideration as is possible, although, as shown by Mr. Wood, data at other points in the same basin may be utilized by applying certain corrections. Outside of the same basin,

* District Engineer, United States Geological Survey, Water Resources Branch, Boston.

however, the conditions of physiography and topography may vary so widely as to introduce large uncertainties, even though the amount of precipitation may be practically the same.

Fig. 4, "Duration Curves for the Middle Branch of the Westfield River at Goss Heights, Mass., and the Quaboag River at

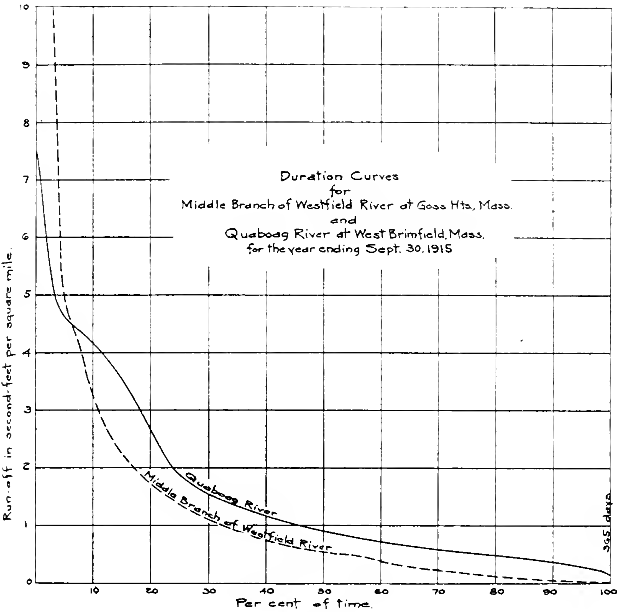


FIG. 4.

West Brimfield, Mass., for the Year ending September 30, 1915," shows the characteristic difference in flow of these two streams. The stations are only about thirty miles apart, the average annual rainfall probably differs not more than 5 per cent., and the average run-off for the year in second-feet per square mile is very nearly the same for the two streams, yet it may be seen that the distribution of flow, as expressed in per cent. of time for which the same unit run-off is available, varies widely. It might be possible to supplement and extend short-term records at one place by means of comparisons with long-term records at a station not too far distant. Rainfall records alone would, however, never provide a safe means of estimating the distribution of run-off throughout the year. The writer is familiar with one locality having a rainfall of over 100 ins. a year, which is absorbed to such an extent that there are no perennial streams. This is an extreme case, but illustrative of the uncertainties that will occur in basing power estimates on rainfall alone.

When the base data concerning run-off have been obtained, the question naturally will arise as to the manner in which these shall be used, — whether in the form of duration or deficiency curves, mass curves, or by some other method. The duration or deficiency curve is probably the method most commonly used in a power study, and, although it may be plotted in various ways, it requires the use of daily discharge values. If the load factor is known or assumed, and sufficient pondage provided for, then the unit rate for a longer period may be used. In order that the base data may be available for whatever method is desired, the stream flow records as published in the Water-Supply Papers of the United States Geological Survey are arranged in tables giving the daily discharge in second-feet by days. Additional tables giving the average flow for each month, together with the maximum and minimum values for the month, and computed values of run-off in second-feet per square mile and depth in inches on drainage area, are published. For sections of the country where irrigation is practiced, the run-off in acre-feet is also given. With the base data arranged in this form, it is possible for the engineer to use whatever method he desires in making his power studies, and with publication the detail records become available for use by engineers in years to come without the delay and inconvenience of securing special copies when data are needed for analyses of stream flow.

About two years ago the Survey adopted the so-called "climatic" year, ending September 30, as the basis for annual computations, and the records as published in future Water-

Supply Papers will cover the period from October 1 to September 30. In order that records previously published on the calendar-year basis may be readily available for comparison with the present climatic-year system, the back records at the more important stations are being revised and republished on the climatic-year basis. Water-Supply Paper 415, containing a large amount of run-off data for rivers of Massachusetts, will soon be available, with the records arranged in this form. This division of the year will doubtless fit natural conditions more closely in some sections of the country than in others, but for the eastern part of the United States, and especially New England, it seems likely to give better results than the calendar year. On October 1 conditions are likely to be more nearly the same on consecutive years than can be expected on January 1, when the water equivalent in the form of snow and ice, which may be carried over from December to January, may range from 0 ins. to 8 ins. or more. Also, by having the computations for the ice period, which may extend from December to March, in one continuous group, much better results are obtained than when the year begins and ends with this uncertain condition. This latter feature would, of course, not be as pertinent to records kept at power plants as to river gaging stations, where the stage-discharge relation may be affected by the ice. There are other factors in favor of the climatic year, such as the preparation of the reports containing the data, which are perhaps better appreciated by the engineers who have to collect and assemble the material, than by those who use them for reference.

MR. GLINES* (*by letter*). — After reading through Mr. Wood's very valuable paper, the thought occurred that the objections to several of the methods mentioned, but discarded, might be overcome, and further refinement introduced into the accepted method, by the use of a different type of average.

Quetelet, a Belgian, in his study of astronomical and meteorological phenomena, was led to the discovery that the recurrence of all natural phenomena tended to fluctuate about a norm known as a *mode*, and that the tendency was for the number of occurrences to fall either side of this mode with mathematical

* With Stone & Webster Engineering Corporation, Boston.

regularity. He further found that, if the number of occurrences or instances were plotted as ordinates, the result would tend to approximate the binominal curve corresponding to that given by the mathematical law of probability or chance. Another way of defining the mode is as the position of greatest density or that factor which occurs the greatest number of times. Therefore, in any prediction of the recurrence of stream flow or rainfall, the principal factor we are interested in is that run-off or precipitation which has occurred the greatest number of times in the past. It is obvious that the arithmetical mean, in those cases where the fluctuations are great one side of the median, will not coincide with the mode. Just how much this may vary in an actual case it is proposed to show.

The twenty-year daily flow records for the Connecticut River at Holyoke for January were used in the following discussion. Table 4 shows the number of occurrences for the given rates of flow for the 20-year period between 1880 and 1899 and the 10-year period between 1890 and 1899. In the 20-year period, between 7 500 — 7 999 sec.-ft. occurred the greatest number of times, and the same is true for the 10-year period. We find that in the first period there are three distinct modes. In analyzing the mode between 2 500 — 2 999 sec.-ft. we find that while it occurred 43 times in the first 10-year period, Table 5 shows it occurred 26 times in 1880 and 17 times in 1882 and rarely if ever occurred in any other years. Undoubtedly this flow is abnormal. It might have been caused by ice, or, since it is recorded in the first three years of the record, may be an error. Therefore for the purpose of this discussion this mode may be neglected. Evidently the mode must lie somewhere between 6 000 and 7 999 sec.-ft. In order to locate the mode, smaller groupings were taken until it was finally found to be 7 750 sec.-ft. Now the arithmetical mean, which is the summation of the daily flows divided by the total number of days, is 9 827 sec.-ft. This shows a difference of over 21 per cent., which is certainly appreciable, and, when we consider it may throw our final analysis of a water supply or power study off by this amount, its importance is seen. The actual case taken is probably a very conservative one because it involves records over a long period. The smaller the number of records at hand and the greater the magnitude of these records one side of the median, the greater will be this difference. On the other hand, the more records we have over longer periods, the more compensating this discrepancy becomes and the closer the arithmetical mean approaches the mode. In this particular instance it is obvious that the arithmetical mean is too greatly affected by the comparatively small number of occurrences at a high rate of flow. The mode, on the other hand, is not affected by these abnormal occurrences but is the common or most frequent occurrence. The accompanying curve (Fig. 5) illustrates how the

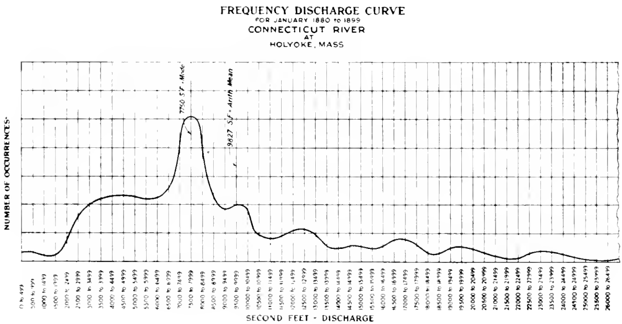


Fig. 5.

high flows of unfrequent occurrence affect the location of the arithmetical mean. It further illustrates how unfrequent the flows may be where the arithmetical mean lies. Many practical applications of this curve may be suggested, such as the study of relay and secondary power possibilities. It is believed that the mode would be a much better type of average to use in comparisons of adjacent drainage areas.

The question as to how far back records should extend, and what percentage of error may creep in by using short-term records, is one which while pertinent to the subject would form a discussion in itself.

It should be pointed out that there might be a case where there is not a well-defined mode, in which case the type of average used becomes a matter of judgment.

A more complete discussion of this type of average may be found in any book on statistics. Bowley's "Elements of Statistics" has a very good discussion. Dr. M. T. Copeland, of the Harvard Business School, proposes to publish this fall a book on "Statistical Methods" which will contain many practical applications of this method to ordinary business problems, so that the average business man is destined to hear a great deal about this type of average in the very near future. Statisticians, economists and sociologists have used this type since its discovery by Quetelet. Exponents of scientific management are using it in fixing standards of operation from and at which bonuses, etc., are figured.

TABLE 4.

10- and 20-Year Run-Off Records — Connecticut River at Holyoke Arranged in 500 Sec.-Ft. Intervals.

Number of Occurrences.

| | 20-Yr. | 10-Yr. | | 20-Yr. | 10-Yr. |
|---|---|---|---|---|---|
| 0 — 499 | 3 | 0 | 10 500 — 10 999 | 8 | 3 |
| 500 — 999 | 6 | 1 | 11 000 — 11 499 | 8 | 5 |
| 1 000 — 1 499 | 2 | 1 | 11 500 — 11 999 | 11 | 7 |
| 1 500 — 1 999 | 1 | 1 | 12 000 — 12 499 | 10 | 6 |
| 2 000 — 2 499 | 6 | 3 | 12 500 — 12 999 | 13 | 7 |
| 2 500 — 2 999 | 47 | 4 | 13 000 — 13 499 | 4 | 3 |
| 3 000 — 3 499 | 25 | 19 | 13 500 — 13 999 | 9 | 2 |
| 3 500 — 3 599 | 13 | 12 | 14 000 — 14 499 | 2 | 1 |
| 4 000 — 4 499 | 16 | 14 | 14 500 — 14 999 | 9 | 7 |
| 4 500 — 4 999 | 23 | 18 | 15 000 — 15 499 | 5 | 3 |
| 5 000 — 5 499 | 23 | 14 | 15 500 — 15 999 | 3 | 0 |
| 5 500 — 5 999 | 21 | 11 | 16 000 — 16 499 | 6 | |
| 6 000 — 6 499 | 24 | 21 | 16 500 — 16 999 | 4 | |
| 6 500 — 6 999 | 22 | 11 | 17 000 — 17 499 | 9 | |
| 7 000 — 7 499 | 49 | 16 | 17 500 — 17 999 | 6 | |
| 7 500 — 7 999 | 50 | 24 | 18 000 — 18 499 | 3 | |
| 8 000 — 8 499 | 30 | 13 | 18 500 — 18 999 | 1 | |
| 8 500 — 8 999 | 23 | 8 | 19 000 — 19 499 | 6 | |
| 9 000 — 9 499 | 18 | 10 | 19 500 — 19 999 | 5 | |
| 9 500 — 9 999 | 22 | 9 | 20 000 — 20 499 | 4 | |
| 10 000 — 10 499 | 22 | 10 | 20 500 — 20 999 | 3 | |

7 750 = Mode. 9 827 = Arith. mean. 21 ± % = Difference.
Forty-six instances over 21 000 sec.-ft. in 20-year period.

TABLE 5.

ANALYSIS OF FLOWS BETWEEN 2 500–2999 SEC.-FT.

| | | | | | |
|---|---|---|---|---|---|
| 1880 | 26 | 1887 | 0 | 1894 | 0 |
| 1881 | 0 | 1888 | 0 | 1895 | 2 |
| 1882 | 17 | 1889 | 0 | 1896 | 0 |
| 1883 | 0 | 1890 | 0 | 1897 | 0 |
| 1884 | 0 | 1891 | 0 | 1898 | 0 |
| 1885 | 0 | 1892 | 0 | 1899 | 0 |
| 1886 | 0 | 1893 | 2 | | |

MR. BARROWS * (*by letter*). — The writer has read with interest the paper of Mr. Dana M. Wood on "Power Estimates from Stream Flow and Rainfall Data," published in the March, 1916, JOURNAL, in which outlines of numerous methods in use for solving problems relating to estimates of power are comprehensively presented.

The writer regrets that, owing to pressure of other matters, he is not able to add materially to the discussion of this paper, but will comment briefly on certain features.

*Use of Precipitation Data.*

Where data of run-off covering a considerable period of years are available at or near the power site, power estimates can be made with considerable certainty. The opposite extreme occurs in the case where little or no run-off data are available and where resort must be had to the use of precipitation data. The writer has found in numerous studies of this kind that monthly ratios of run-off to precipitation are of little value, as in a given month these ratios will vary very widely, even for the same total precipitation during the month, depending on the distribution of the precipitation during the month and the conditions for some time prior to the month in question. By dividing the "water year" into perhaps three periods, better results can be obtained in cases where storage is contemplated and the natural flow over short periods of time is not essential. A more satisfactory method of treatment in such a case, however, often

* Consulting Engineer, Boston.

consists in estimating the water losses and subtracting these from the precipitation to get the probable run-off. The water losses from land area may be considered substantially as (1) soil evaporation; (2) interception losses (that is, rainfall caught by vegetation and evaporating before reaching the ground); and (3) transpiration losses, or practically the requirements of growing vegetation.

As regards soil evaporation, a considerable amount of data is available from various lysimeter measurements. Interception losses have been determined only to a very slight extent, although some data are available on this subject from experiments made abroad. Transpiration losses have been determined fairly well for different kinds of growing crops by Messrs. Briggs and Shantz.*

To make an intelligent estimate of run-off based upon precipitation, taking into account the above factors, requires of course a knowledge of the drainage area and of the characteristics which affect the above factors.

Obviously it is difficult or impossible to measure separately these different losses on a given drainage area, but their determination by experiment upon small areas and the checking up of estimated losses with actual run-off measurements affords an interesting field for research in which there is opportunity for much effort.

The writer questions the desirability of any general assumption that precipitation varies directly with elevation. While there is usually an increase in precipitation with elevation, at least in the general vicinity of the Atlantic and Pacific coasts, a much safer method of procedure consists in plotting a curve in which the arguments are elevation and, say, mean annual precipitation, to ascertain what precipitation is likely for a given elevation, selecting data from stations adjacent to the locality in question.

*Storage Studies.*

Studies of the effect of storage capacity on stream flow can be divided into two general classes: (1) Where the storage reser-

* See Bulletin 281, U. S. Dept. of Agriculture, Bureau of Plant Industry.

voir is at some distance from the power plant. (2) Where it is closely adjacent to or at the power plant.

In the first case, where the reservoir is at some distance from the power plant, the use of the mass curve is not practicable, but studies are best made by means of a hydrograph plotted on the basis of the yield of the uncontrolled portion of the drainage area, between the reservoir and the power plant, accompanying the hydrograph by tabular computations and a reservoir depletion curve, as noted by Mr. Wood.

In the case where the reservoir is at or near the power plant, the mass curve method is useful and probably better adapted. The results of a mass curve study can be very effectively presented in what may be called "resultant curves," which show the relation between any given amount of storage capacity and the resulting dependable flow of the stream.

In operating storage there are two extremes in method, — (1) that in which the attempt is made to obtain a maximum of primary power, which will require storing water over more than one season; (2) the other method, and that more commonly used, consists in practically emptying the storage reservoir each season. This will commonly mean a greater output in total kilowatt-hours annually, but a lesser amount of primary power. As a rule, however, this second method is more attractive financially, especially where the plant is tied in with a system where auxiliary steam is available in the low-water season.

*Refinement of Computations.*

The futility of a degree of precision, in computations relating to power estimates from stream flow, greater than that obtainable with the slide rule, is evident, and the writer believes that more care in this respect should be taken generally by engineers, — especially in presenting the final results of investigations and estimates, — not to retain superfluous significant figures which, although perhaps impressive in some cases to the layman, really mean nothing.

As Mr. Wood states, it must be kept in mind that power estimates are based upon past records, and are simply guides to assist the judgment in conservative estimates of the probable future output of a power plant. They involve the basic uncertainty of all estimates relating to factors dependent in the broad sense upon meteorological conditions which cannot be accurately predicted in advance.

Mr. Wood * (*by letter*). — In his discussion Mr. Hazen has suggested a method of analyzing stream-flow data which apparently allows of a ready comparison between records in different basins, by using the rates of flow as percentages of the mean flow. While the writer has not had time to make any extensive comparisons of records by this method, those he has made leads him to believe that the suggestion will prove a very useful one.

In applying the results of such comparisons to a basin where few or no run-off records are available, it appears to be necessary to arrive at a fairly reliable estimate of the mean flow as a starting point, afterwards assuming its distribution throughout any given period of time similar to some one of the known cases.

After giving considerable thought to this method, the writer is of the opinion that, for purposes of making power estimates, the results might perhaps be presented in slightly different form from that suggested by Mr. Hazen. The flow corresponding to any given " per cent. of time available " can first be picked off from the duration curve of flows and then its percentage relation to the mean flow computed, rather than vice versa. This would facilitate putting the flow records into the useful form indicated in the original paper.

As an example of this slight amendment to Mr. Hazen's valuable suggestion, Table 6 is presented giving the results of an analysis by four of the methods cited in the original paper, of a 38-year run-off record of the Mississippi River at Nashville, Ia., the total drainage area being 119 000 square miles.

In addition to the interesting variations in percentages of mean flow available for various percentages of time for such a large drainage area and long-term record, this table also shows clearly the differences resulting from the use of four different methods of analyzing the basic data. It indicates the greater reliability of the daily flow analysis.

* Author's closure.

TABLE 6.

PERCENTAGE OF MEAN FLOW AVAILABLE FOR GIVEN PER CENTS. OF TIME FOR DIFFERENT METHODS OF ANALYZING BASIC DATA.

| Per Cent. of Time Flow was Available. | Averaged Calendar Mos. for Period of Record (38 Yrs.). | Averaged by Mos. when arranged in order of Dryness but by Calendar Years. | Mos. arranged in order of Dryness regardless of Calendar Years. | Days arranged in order of Dryness (Daily Duration Curve Method). |
|---|---|---|---|---|
| 100 | 19.5 | 19.5 | 19.5 | 15.6 |
| 95 | 44 | 34 | 30 | 28 |
| 90 | 48 | 38 | 35 | 32 |
| 85 | 50 | 43 | 38 | 36 |
| 80 | 51 | 49 | 42 | 40 |
| 75 | 58 | 56 | 47 | 44 |
| 70 | 72 | 63 | 54 | 49 |
| 65 | 78 | 66 | 58 | 54 |
| 60 | 80 | 71 | 64 | 61 |
| 55 | 81 | 76 | 71 | 67 |
| 50 | 84 | 81 | 79 | 75 |
| 45 | 88 | 86 | 89 | 83 |
| 40 | 102 | 96 | 100 | 94 |
| 35 | 116 | 109 | 110 | 105 |
| 30 | 124 | 124 | 123 | 118 |
| 25 | 142 | 140 | 135 | 135 |
| 20 | 163 | 155 | 151 | 155 |
| 15 | 166 | 171 | 167 | 178 |
| 10 | 171 | 186 | 195 | 205 |
| 5 | 174 | 212 | 245 | 249 |
| 0 | 408 | 408 | 408 | 491 |

Mr. Herschel calls attention to the dangers of relying upon rainfall data for the determination of run-off. In the original paper it was stated that such methods should be used only as a last resort, but an attempt was made to call attention to the value of rainfall statistics in determining the characteristics of the period of years covered by any particular run-off records.

For example, how could one feel assured that the twenty years' run-off record at Holyoke is typical of a much longer period of years, unless it is studied in connection with rainfall data? Unfortunately there are so few records covering a longer period of years than those at Holyoke that, even with the help of Mr. Hazen's suggested method of comparing run-off records, much uncertainty would still exist regarding the probability of recurrence unless the two sets of data are considered together.

The several methods of using rainfall and run-off data were introduced in the original paper for the purpose of showing briefly the differences in results likely to be obtained by their use. In the many engineering reports which the writer is constantly reviewing, he has seen used all of the methods of analyzing run-off data cited; and that engineers continue to use methods of doubtful value would seem to be reason enough for calling attention to the possible variations in results, and to suggest a method which the writer has worked out and had the opportunity to compare with actual operating conditions.

Briefly, the daily duration curve method has been employed whenever possible, but, in lieu of that, the method of arranging the run-off by months in order of dryness regardless of the occurrence by calendar years has been found to give the most reliable results, especially if a reduction of a few per cent. is arbitrarily made for correction to a daily basis.

The writer would not like to see the United States Geological Survey suppress the publication of the basic flow data, because many important questions arise which can only be answered by their study. It is understood that, in the future, duration flow tables are to be added to the other published data, which is to be commended. Considerable redundancy might be avoided in the publications if a system of loose-leaf bulletins was adopted, similar to that used by many of the large manufacturers in publishing their catalogues, thus facilitating filing the records of one basin together.

Mr. Herschel, in his discussion on power estimates, has taken the special case of the point of view of the manufacturing concern with fairly steady load conditions, while the writer endeavored, by means of his power curves, to present a general case applicable to all kinds of variable flow and power conditions, with or without pondage available, and with or without relay requirements at times of low or high water, or both.

It is difficult to see why the economical plant capacity is more dependent upon flow conditions than upon financial considerations, the latter involving as they do a study of the market conditions, including the expected load factors.

In central-station practice, the annual load factors realized are usually in the vicinity of 30 per cent. to 50 per cent. rather than 100 per cent. Even in the case of manufacturing industries with reasonably steady load conditions, more than an 80 per cent. load factor is rarely obtained. With many plants tied in together, the load factors will decrease rather than increase, except for short periods of time on the individual plants. Never can a load factor of unity be obtained until the ideal condition is reached when every power user utilizes his full peak demand for twenty-four hours a day, for every day in the month and year.

The minimum daily flow is of importance even in the case of a relayed plant. With given relay capacity, it indicates the total amount of power which can be guaranteed, with given load factor and pondage conditions.

A majority of both industrial and central-station plants can utilize to good advantage a certain amount of "secondary" water power. How much of this secondary power should be relayed is entirely a question of economics, — of dollars and cents. No two cases are exactly alike, so that each must be studied by itself. A general method of making such studies was given in the original paper.

A general "utilization" factor was discussed, which included among other things an allowance for "power factor" and also for "regulation." Each of these problems can be studied by themselves if so desired, the method of developing power curves as suggested allowing of ready corrections for such further detailed analysis.

An interesting problem which the local manager is always facing is that of the use or sale of surplus power at varying load factors, perhaps bringing up such questions as the advisability of further machinery installations. The power curves afford a means of making such studies, but the general theory as presented in the original paper was not complicated by introducing such questions.

In Mr. Pierce's excellent discussion, attention is called to the errors that may arise from applying records in one basin to another. It is unfortunate that we do not always have actual records in the basin under consideration, nor can we sometimes wait the necessary time to obtain them. It then becomes necessary to do the next best thing and make as close approximations as possible from other sources of information.

Mr. Glines' suggestion of the use of the "mode" was received too late to allow the writer to make trial of it in any actual cases. It undoubtedly suggests another convenient tool for making a reasonably correct analysis of run-off data.

In closing, the writer wishes to call attention to the fact that on page 80 he inadvertently omitted mention of the run-off records compiled by the United States Engineer Corps as a useful source for basic data.

## MEMOIR OF DECEASED MEMBER.

### ERASMUS DARWIN LEAVITT.*

Erasmus Darwin Leavitt, honorary member of the Boston Society of Civil Engineers, died in Cambridge, Mass., on March 11, 1916, where he had lived for many years. He was born in Lowell, Mass., on October 27, 1836, and was the son of Erasmus Darwin and Almira (Fay) Leavitt.

Mr. Leavitt's education was in the public schools of Lowell, and in 1852 he entered the Lowell Machine Shop as an apprentice, where he served three years, after which he was employed by Corliss & Nightingale one year. In 1858 he was employed by Harrison Loring at the City Point Works at South Boston, as assistant foreman, and had charge of the construction of the engine of the U.S.S. (flagship) *Hartford*. From 1859 to 1861 he was chief draftsman for Thurston, Gardner & Co., Providence, R. I.

He served in the Navy during the Civil War, in sea service and construction work, and for two years was instructor in steam engineering at the Naval Academy at Annapolis, resigning in 1867.

In 1867 he entered the practice of mechanical engineering, making a specialty of pumping and mining machinery.

His fame may be said to have begun with the installation of the pumping engine at Lynn, Mass. This was followed by the engine for Lawrence, Mass. Both of these engines were tested by some of the best-known engineers in the country, and the high results obtained were of great interest to the profession.

In 1874, Mr. Leavitt was appointed consulting and mechanical engineer of the Calumet & Hecla Mining Company, and held that position until 1904. During this time he designed and supervised the construction of the large equipment for this com-

* Memoir prepared by Charles T. Main and Will J. Sando.

pany. During this period he acted as consulting engineer for many other companies and municipalities.

He was one of the organizers of the American Society of Mechanical Engineers. The Society History says:

"Mr. Leavitt was best known for his notable successes in the design of high-duty compound pumping engines for city water-works service. . . . He served as president of the Society during 1883–84. . . . He positively declined a second term as president on the principle . . . that the honor of the office should be widely conferred."

He was on intimate terms with the most prominent engineers of his active days. He was of a modest and retiring nature, and his acquaintance with members of the Society was not extensive.

Mr. Leavitt as a designer probably did more than any other engineer in establishing sound principles of design and the use of the best of materials in construction, realizing that, while economy in running was to be striven for, reliability of service was more important.

Mr. Leavitt received the degree of doctor of engineering from the Stevens Institute of Technology in 1884. He joined the Boston Society of Civil Engineers, January 21, 1880, and was made an honorary member in 1908.

He was a member also of the following societies: American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers (honorary, 1915), American Society of Naval Engineers (honorary), Institution of Civil Engineers, British Association for the Advancement of Science (life member), Franklin Institute, fellow of the American Academy of Arts and Sciences, New England Water Works Association (honorary, 1906).

Mr. Leavitt married Annie Elizabeth Pettit, of Philadelphia, on June 5, 1867, and he is survived by three daughters, two of whom are married.

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PAPERS AND DISCUSSIONS

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# THE COMMERCIAL FERTILIZER INDUSTRY IN THE UNITED STATES.

By Lester W. Tucker,* Member Boston Society of Civil Engineers.

## Introduction.

A paper by the writer on "The Phosphate Rock Industry of Florida" was read before the Society in June, 1914.† In the subsequent discussion the question was asked as to what was done with the rock after it was received at the fertilizer factory, and how it was used in the manufacture of commercial fertilizer. The reply was that it was too long a story to be answered in an informal way, and the writer, believing that the Society would be interested in this subject, has prepared this paper to give an idea of the extent of the industry of the manufacture of commercial fertilizer in the United States, and a brief description of the method by which the phosphate rock is changed from its natural state to that in which it appears when sold under its many and various names as commercial fertilizer.

## General.

Reliable statistics regarding the fertilizer industry in the United States are very hard to obtain. The Census of 1910

Note. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before November 10, 1916, for publication in a subsequent number of the Journal.

* Managing Engineer, Westinghouse, Church, Kerr & Co., New York.

† Journal Boston Society of Civil Engineers, Vol. I, p. 509.

places the fertilizer industry forty-eighth in rank in the value of products of manufacture, and gives the number of establishments engaged in the manufacture, the number of persons employed and the capital invested as follows:

| | |
|---|---|
| Number of establishments | 550 |
| Total number of persons employed | 21 950 |
| Capital invested | $121 537 451 |

The tonnage of fertilizer used in the various states is given in a report issued by the Department of Agriculture of the United States in 1898, and also in a special bulletin from the same source for a part of the states from 1906 to 1909 and for all of the states from 1910 to 1913 inclusive. The fact that the close of the fiscal year in various states is at different periods causes a wide variation of yearly results in trying to correlate these figures. However, the figures give a fairly good idea of the amount of fertilizer used in each of these various states for the years given.

The growth of the industry in value of product since 1860 is shown by the United States Census for 1910 to have been as follows:

| Year. | Value of Production. |
|---|---|
| 1860 | $891 344 |
| 1870 | 5 815 118 |
| 1880 | 23 630 795 |
| 1890 | 39 180 844 |
| 1900 | 44 657 385 |
| 1905 | 56 541 253 |
| 1910 | 103 960 213 |

The increase in value of product from 1905 to 1910 is much greater in proportion than it has been for the previous years shown. This increase has been caused to a great extent not only by the greatly increased use of fertilizer for the cotton crops in the South and for many of the northern states, but also by increase in value of products. Fig. 1 shows that the increase in consumption from 1905 to 1911 is largely due to the increased use of fertilizer in the so-called cotton belt and adjoining states. It will be noted that the annual rate of increase has been nearly

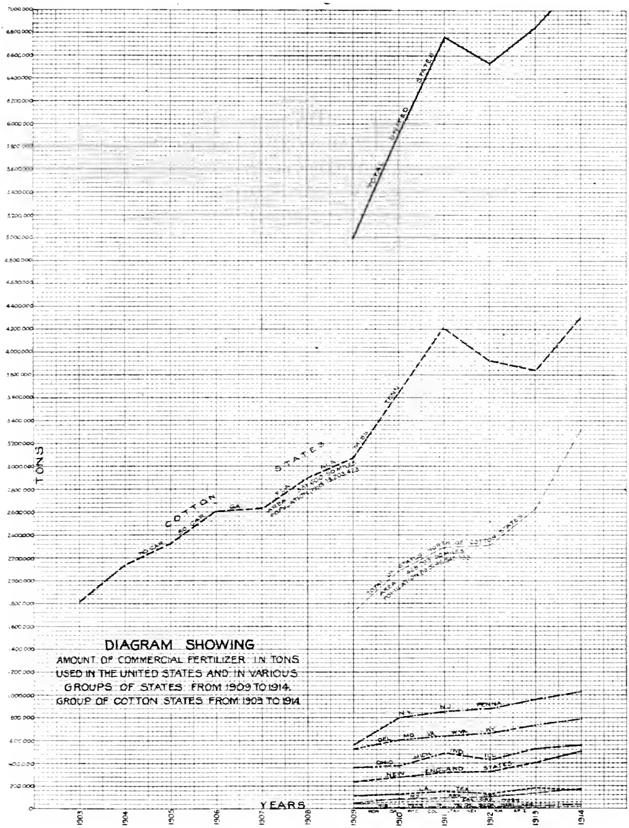



FIG. 1.

the same in both the cotton belt states and the states north of them, if we neglect the abnormal increase of the years 1910 and 1911 in the cotton belt states. This annual increase appears to be, under normal conditions, about 200 000 tons per year in both groups of states.

The number of plants engaged in the industry in the various states is very indefinite. The United States Census for 1910 gives the total number of plants as 550 for the entire United States, while the State of Georgia Year Book for 1913 gives a list of persons and factories engaged in the industry as 415 in that one state alone. Eliminating from this list the cotton seed oil plants and the persons who are simply acting as selling agents for certain mixtures, the total number of plants is reduced to about 135, which, if we take into account the factories recently built, agrees closely with the United States Census Reports for 1910. The figures in the year books of the various states include so many selling agents and cotton seed oil plants that they are not reliable indices of the actual number of manufacturing establishments. From a careful perusal of the number of establishments given in the 1910 Census, and from a personal knowledge of many of the factories in the eastern part of the United States, the writer believes that the figures given in the United States Census for 1910 are practically correct and has adopted them in this paper. This number for the last twenty years is as follows:

| Year. | Number of Establishments. |
|---|---|
| 1890 | 390 |
| 1900 | 422 |
| 1905 | 399 |
| 1910 | 550 |

Grouping the various states in order to study the growth of the industry since the first available statistics were taken in various sections of the United States shows that the greatest consumption has always been in the cotton states. The New England states show a substantial increase, especially in Maine, while the Central states show large gains in the last ten years. The states west of the Mississippi River show a very small consumption, it being very evident that the soil in that section has not yet been exhausted to the extent where commercial fertilizer is necessary. In Texas, one of the greatest cotton-producing states in the South, there is a comparatively small use of fertilizer, which from the 1912 and 1913 reports would not seem to be increasing to any great extent. California shows a small increase, which it is expected will continue in the future, as the use of fertilizer in the fruit and vegetable crops is found beneficial.

The annual increase in the United States for the past six years has been an average of about 480 000 tons per year, the maximum increase being from 1909 to 1911, when the increase was 900 000 tons per year. The increase in the future, while subject to the same business conditions as all other industries, must, as a whole, continue to show a substantial growth if the agricultural interests are to be maintained at the same rate of progress in the future as in the past.

## History.

The manufacture and use of what is officially known as commercial fertilizer in the United States dates back to about the year 1840, when a commodity known as Peruvian guano was brought into the United States from the islands off the west coast of South America. Some years later, in the early sixties, the manufacture of a fertilizer made from fish and sold under the name of fish guano was begun, and several other mixtures under various names were also put on the market about this time. The discovery of potash salts in Germany and the teachings of Dr. Von Leibig were followed by the discovery of phosphate rock in South Carolina in 1867. Acid phosphate was then first introduced as a part of these fertilizers, and it is with the manufacture of this kind of commercial fertilizer that this paper will deal directly.

The enormous use of commercial fertilizer in recent years has been possible only through the discovery of the phosphate rock in the United States and the potash salts of Germany, the supply of Peruvian and other guanos being practically exhausted, and the fish products are nearly all used in conjunction with the phosphate. It is the phosphate rock and potash which to-day makes the manufacture of commercial fertilizer an important industry.

## Manufacture.

The manufacture of commercial fertilizer is practically the same wherever it is carried on. Factories are located all the way from Maine to the Gulf and from the Atlantic to west of the Mississippi River. Several cities have become important centers for the manufacture of fertilizer, being chosen by the various companies on account of their superior locations for receiving and forwarding material as well as for distribution centers.

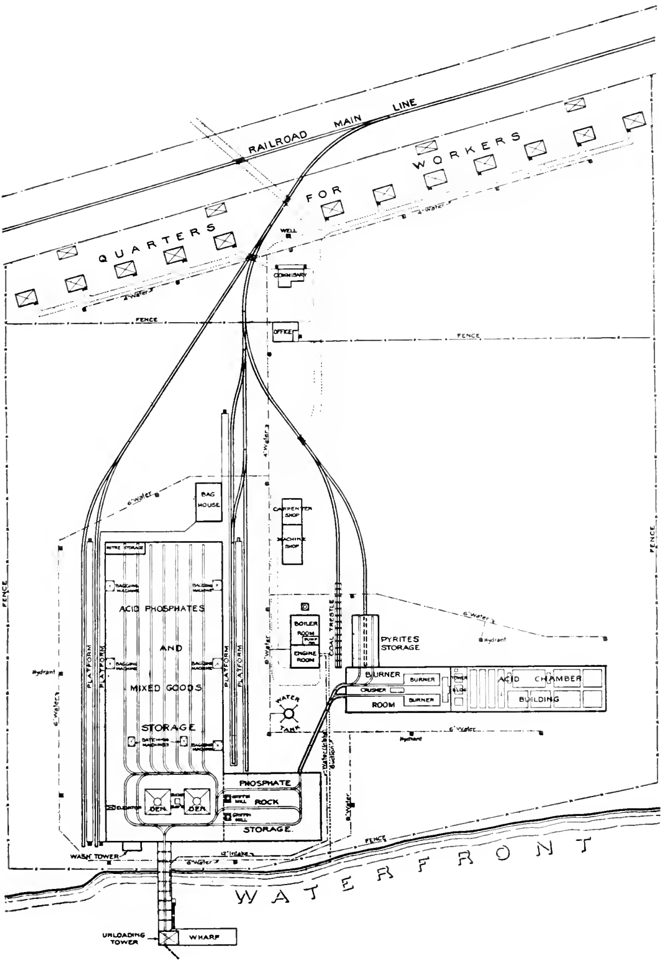
As was described in a former paper, phosphate rock is shipped from the mines in as nearly a dry condition as is possible and is received at the various factories and kept in this same dry condition until it is ready for the grinding or pulverizing.

A complete fertilizer establishment consists, in a general way, of a factory building with its attendant storage sheds, acid plant, bag factory, power plant, office, shops and general quarters for the employees, together with facilities for receiving raw material and shipping out the finished goods. Many of the factories do not have an acid plant connected with them, buying their acid in bulk as needed.

A typical cross section for a factory is shown by Plate I to give an idea of how the rock is handled from the time it leaves the ship or car in which it is received from the mine until it is finally deposited in the shape of acid phosphate or base goods in the storage sheds.

A description of an acid plant is not necessarily a part of this paper, but it can be said that such a plant consists of a furnace room in which are located the furnaces for burning the sulphur or pyrites, the towers for denitration of the gases and acid, and chambers for the condensation of the gases to acid. Roughly speaking, a ton of acid is required for each ton of phosphate rock used. The acid must commonly used is sulphuric acid ($H_2SO_4$) at a density of 50 degrees, Bo. scale.

The fertilizer factory consists, for the major part, of storage space. Most of the factories are obliged to furnish storage for the equivalent of nearly their entire year's output. For example, a factory may have an output of 60 000 tons, and storage space must be supplied for acid phosphate and base goods for




# TYPICAL LAYOUT FOR FERTILIZER FACTORY.


FIG. 2.

practically this total amount, as the shipping season for nearly all the factories lasts only about six weeks and there must be on hand, at the beginning of the shipping season, acid phosphate, base goods and mixed goods for practically the total output of the factory. A factory can be said roughly to consist of storage for phosphate rock, mixing floor and machinery, dens, conveyors, tankage, batching and bagging machines, and storage for acid phosphate, base and mixed goods. The typical cross section of a factory shows in a very general way how the materials are handled from the time they are received at the factory until they are shipped out in the finished state.

The phosphate rock, upon being received at the factory, is taken from the vessel or car and placed in the storage pile. The first process which it goes through is that of grinding or pulverizing, the rock being taken from the storage pile and put through a Griffin mill or some of the later types of mills used especially for phosphate rock, such as the Bradley, Raymond, Kent or Sturtevant mills, which pulverize it until it passes through the No. 100 mesh screen which is a part of the mill. From these mills the pulverized rock passes by means of screw conveyors and elevators to the storage bin over the mixing floor. Also over the mixing floor is located an acid tank for the storage of sulphuric acid. Immediately below the ground-rock bin is located a weigh hopper for weighing the rock used, and a small measuring tank for measuring the acid used. Immediately below the mixing floor, and on a level with it, is the mixer. Mixers are of various makes, but are similar in operation. They consist of round iron cylinders about 18 in. deep and 8 ft. in diameter in which are installed paddles or stirrers working in opposite directions. These mixing pans are located directly over large receptacles called dens into which the mixed materials are dumped. The method of operation is to dump into the pan the proper amount of ground rock from the weigh hopper, following it immediately with the proper amount of acid, which is carefully measured. The pan is then started and run the necessary length of time to mix the contents thoroughly, which are then dumped into the den. This procedure continues until the den is filled.

In the manufacture of base goods, the proper proportion of ammoniates is added to the contents of the mixing pan with the acid and phosphate rock so that the whole mass may become thoroughly mixed before going to the dens. The dens are made airtight, except for a flue leading to the wash tower in which is located a fan carrying off the fumes arising from the chemical changes which take place. These fumes are condensed in the wash tower by means of sprays in order to prevent the obnoxious odors from being generally spread through the atmosphere. Many of the factories have gone to a great deal of expense in building wash towers so that the fumes shall cause as little trouble as possible to the surrounding country, and there are many plants where, a few hundred feet away, it would scarcely be known that any such operation was being conducted.

It will be noticed that careful weighing and measuring of all stock used is one of the most noticeable things about one of these factories.

The mass remains in the den for about twelve hours, after which time it has become thoroughly cooked, and is then removed to piles in the storage buildings until it is ready to go to the batching machines. A batching machine consists of a boot for the deposit of the various ingredients which are to be batched, elevators, shaking screens, mixing machine and pulverizers. From the boot the ingredients are elevated and passed over screens to eliminate all hard lumps, the material which passes through the screens being passed through the mixing machine and then taken by an elevator and carried to a hopper on the top floor. The lumps or balls which are rejected by the screen are passed through a cage mill or pulverizer, where they are broken up and again passed through the boot and mixer before going again over the screens. In the batching machines the various potash, nitrate and other ingredients to make up the proper mix are added. The batched material is then stored until ready for bagging. It is then taken from the storage piles, passed through the bagging machines, which are somewhat like a batching machine, but without the mixer, where it is again pulverized, the lumps being taken out and only the fine material going into the bags. The bags are so arranged that they are filled immediately from the spouts, automatically weighed, the bags sewed and placed in the car for shipment. In some factories the batching and bagging machines are combined, but the continuity of the operation is somewhat interfered with when this is done. A batching machine will batch from 40 to 50 tons per hour, while a bagging machine with two spouts usually bags from 20 to 25 tons per hour. In the shipping season these bagging machines are running practically twenty-four hours a day, for, as before stated, the entire tonnage of one of these factories has to be turned out in the very short shipping season which precedes the planting time in the various communities. Goods are seldom batched until they have been from seven to ten days out of the dens, as the tendency to lump is very much greater if batched sooner than this. Fertilizer will not set after being milled a second time, and it is for this reason that the batched goods are put through the pulverizer a second time.

## Commercial Grades.

There are so many different grades of commercial fertilizer on the market that it would be impossible to give any description of the various formulas by which they are manufactured. All of the fertilizers in which phosphate rock is used are based on three principal ingredients, — acid phosphate, ammoniates and potash, —and it is the number of parts of each one of these three ingredients which give to the fertilizers as sold their various names. In practically all the states of the Union it is now necessary to stamp on the bag the formula under which the fertilizer is manufactured. In several of the states each bag has to have a state tag attached, certifying as to the formula under which it is mixed, the number of pounds in the bag, and the exact parts of each ingredient going in to make the mix. In New Jersey, Georgia, South Carolina, Alabama and some other states, the sale of these tags by the state practically fixes the amount of fertilizer sold within the state. In other states the formula and weight must be printed in letters at least $\frac{3}{4}$ in. high on the outside of the bag. In nearly all of the states the requirements are such that inspectors from the various agricultural bureaus have the right to make an analysis of the contents of any single bag, and if it is found to be at variance with that shown on the tag or the printed formula on the bag, the manufacturer is subject to heavy fines. For interstate traffic the United States Department of Agriculture has various inspectors who go into any factory and take samples of the mixed goods for analysis to see that they are as stated in the formulas. In fact, it is safe to say that the contents of a bag of fertilizer are as near what the formula on the bag states as it is possible to make it, and this applies wherever it is sold in the United States.

For one who is not actively engaged in the manufacture of this product and who passes through a factory on a casual visit and sees the number of men rushing about with wheelbarrows, one with potash, one with nitrates, another with additional ammoniates, it is impossible to realize that at every machine where these various loads are dumped, everything has been carefully weighed and every particle of the ingredients going into a single batch will check out in the end with the formula which is printed on the bag. To get these various mixes right and to keep them right in their various handlings through the factory with the class of help which is here employed, would seem to be almost impossible, and that it is done and that the formulas are very seldom found to be wrong when the fertilizer is inspected shows the thoroughness of the organizations by which the various factories are managed.

An industry connected with all of the plants where any large amount of fertilizer is manufactured is the making and printing of the bags in which the finished product is shipped. The jute from which the bags are made comes in large rolls and the bags are cut, sewed and the name and formula printed on them in the bag factory. This part of the industry is hardly to be classed as coming under the general head of this paper, but it is an absolute necessity and of considerable importance, and at many plants which have been visited great care and ingenuity have been shown in the ways and means of making and printing these bags.

## Power Plants.

The power plants connected with the various factories vary in size and equipment according to the necessities of the plant. As a general thing, it can be said that these are up to date and entirely adequate to the necessities. Of course many of the older plants have machinery which is rather out of date, but it is of such efficiency that will not warrant changing it. The power required varies so much at the different seasons in the year, being a maximum during the shipping season of only six or eight weeks and a minimum practically the rest of the time, that a plant is not justified in installing new equipment for this short season when the old will carry them through and is perfectly adequate for ten months in the year. All the modern plants are electrically driven, having individual motors for all machines, so that the [illegible] for all parts of the factory is limited to the requirements of each machine.

One of the necessary parts of the power equipment is the pumping plant, which has to be of a capacity sufficient not only to supply the wants of the factory, but also to keep the fire protection system under pressure at all times.

## Laboratory.

At all of the plants where goods are manufactured, a laboratory is maintained and chemists are engaged the year around in testing the goods, checking formulas and in experimenting on changes in existing formulas. As practically all formulas used have to be registered in the various states where goods are sold, this department is one of the most important and one in which the greatest efficiency has to be maintained.

## Labor and Efficiency in Manufacture.

The writer has visited nearly one hundred fertilizer plants located in all parts of the United States. In the factories of the northern states the lower classes of white labor are generally used, while in the southern states negro labor is employed exclusively. In the southern part of California, the Mexican peon is employed, while in the vicinity of San Francisco, Chinamen

PLATE I.
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
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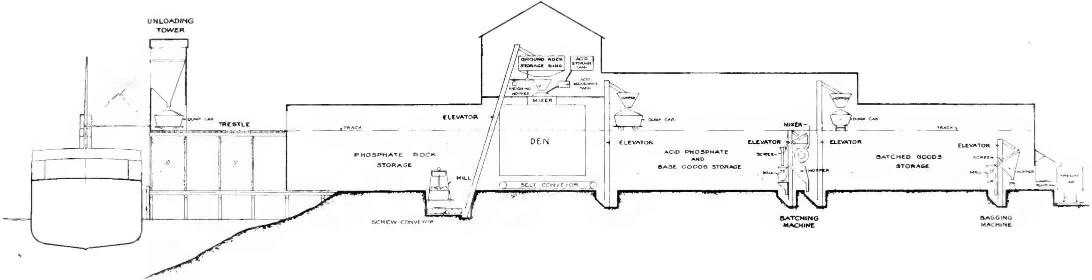
TUCKER ON FERTILIZER INDUSTRY.

# DIAGRAMATIC CROSS SECTION OF FERTILIZER FACTORY.



of the lower class are used. In all cases the labor may be said to be of about the lowest class, and when it is considered that with this class of labor, superintendents and foremen in these various factories ship thousands of tons of fertilizer, mixed in some cases to as many as forty different formulas from one factory, and that these mixtures are made with practically no mistakes, it must be noted that the efficiency of the foremen and superintendents is equal to or better than that of those employed in what are usually classed as high-grade factories.

It was observed in visiting many of these plants that the superintendents and higher class foremen were not only of the better grade of Americans, but were in many cases college-bred men, quick, sharp and aggressive, working during the rush season twelve or fifteen hours a day, and making good in an industry which would not seem to be as attractive as many others which they might have chosen, but which from its very exacting requirements keeps them in a high state of efficiency and up to a stiff standard of responsibility all the time.

The condition of both buildings and equipment of the plants which have been visited can be said to have been maintained equal to that which has prevailed in many other industries which the writer has visited in the last several years. The large number of new plants which have been started since 1910 is especially noteworthy, and while there has been a slight set-back for the last year or so, due to delayed sales resulting from the present war and lack of potash from Germany, it can be said that few industries present a better outlook for future growth. In conclusion, it can be said that with the great increase in the use of commercial fertilizer in the United States which will be necessary to maintain the output of the soil and which will result from broader education in the use and economic value of fertilizer, the engineer, be he civil, mechanical, electrical or chemical, will be called upon more and more to work out the general ways and means and the detail of the various parts of this industry from the mining of the rock to the delivery of the finished product to the consumer.

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PAPERS AND DISCUSSIONS

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# THE SEWAGE DISPOSAL PROBLEM CONFRONTING THE CITY OF PHILADELPHIA.

By W. L. Stevenson.*

(Presented before the Sanitary Section, June 7, 1916.)

## Abstract.

The purpose of this paper is to show the present conditions at Philadelphia as related to sewers, water courses and water supply, and to describe the plan adopted for the collection, treatment and disposal of the sewage which provides for the division of the city into three main sewerage areas, furnished with high- and low-level intercepting sewers and disposal works with the degree of treatment deemed necessary for the sewage.

Of the three divisions, the Northeast is selected for description of proposed sewerage works, as it is nearest the source of the city's water supply, and, as funds are now available for the Frankford Creek high-level intercepting sewer, it is described in more detail to give the important features of the design of the entire plan.

## Introduction.

*Location of Philadelphia.* — The city of Philadelphia is situated on the west bank of the Delaware River about one

Note. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before November 10, 1916, for publication in a subsequent number of the Journal.

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hundred miles from the Atlantic Ocean. The Schuylkill River and Frankford and Pennypack creeks flow through the city, and Poquessing and Cobbs creeks form its boundaries respectively on the northeastern and western sides.

The city embraces 130 square miles and now has a population of 1 700 000. The estimates indicate a population in 1950 of 3 000 000.

*Present Sewers.* — The present sewers are on the combined system, except on the watershed of the Schuylkill River above Fairmount Dam and its tributary, Wissahickon Creek, where the separate system has been installed, from which rain water is discharged directly to the watercourses and sewage conducted by an intercepting sewer, the outlet of which is in the Schuylkill River below Fairmount Dam.

An intercepting sewer has been built along Cobbs Creek to convey the dry-weather flow and first flush of rain water from tributary combined sewers to a point on the creek below the built-up part of the city.

Intercepting sewers, a pumping station and a treatment works for the populated part of the watershed of Pennypack Creek near its mouth were completed in 1912. These works of 2 000 000 gals. a day capacity consist of coarse screens, grit chambers, Emscher tanks, a percolating filter, disinfection apparatus and a final settlement basin. They produce a clarified, non-putrescent and nearly sterile effluent, protecting from local pollution the water of the Delaware River at the Torresdale intake, which is only 2 000 ft. above the mouth of Pennypack Creek.

As these works treat about 1¼ million gallons of sewage out of the present estimated 400 million gallons a day produced by the city and discharged into the watercourses, the condition of these streams is of interest and has a direct bearing upon the order of procedure in constructing the proposed intercepting sewers.

*Condition of Streams.* — The entire watershed of Poquessing Creek and the watershed of the upper part of Pennypack Creek are sparsely settled, and these creeks are, therefore, normal, clean streams. The Wissahickon Creek and the Schuylkill

River above Fairmount Dam, being protected from sewage pollution from Philadelphia by intercepting sewers, are reasonably clean, although the Schuylkill River carries the sewage of a large population from its watershed above Philadelphia. Cobbs Creek is still considerably polluted by sewage from the adjoining county.

Frankford Creek, the Schuylkill River below Fairmount Dam, and the docks of the Delaware River are all seriously polluted both by the sewage discharged into them daily and by decomposing deposits of sewage origin on their beds, caused by insufficient velocity of flow to maintain the sewage solids in suspension.

The Delaware River has a normal flow of upland water of 4 050 sec.-ft. and an extreme dry weather flow of 2 030 sec.-ft. This represents, during normal conditions, 2.4 sec.-ft. upland water per 1 000 persons contributing sewage from Philadelphia alone. The river has a tidal range of $5\frac{1}{2}$ ft., and 2 421 000 000 cu. ft. of water flow past the city in the $7\frac{1}{2}$ hrs. during the ebb tide. The velocity of the water due to the tidal flow is sufficiently high to maintain the sewage matters in suspension, so that the entire bed of the Delaware River at Philadelphia is clean and free from sewage deposits, excepting in the docks.

In this river the city possesses a great natural sewage-oxidizing plant. As the water of the Delaware River reaches the northern or upstream limits of the city, its oxygen content in warm weather is about 80 to 95 per cent. of complete saturation. As it flows past the city and receives the sewage either directly from sewers or indirectly from Frankford Creek and the Schuylkill River, the oxygen content is decreased in summer to an average as low as 12 per cent. of complete saturation during July, August and September, with single samples entirely devoid of dissolved oxygen. Even at such times no offense from odors from the water has ever been noted, except in the docks.

For several miles below the mouth of the Schuylkill practically no sewage enters the river, and the absorbed oxygen and the natural biological agencies of the Delaware River cause a marked improvement in the condition of the water as it flows along toward Chester, ten miles below.

*Water Supply.* — One third of the water supply of the city is obtained from the Schuylkill River above Fairmount Dam and two thirds from the Delaware River at Torresdale near the northern limit of the city. The river water is purified by preliminary and slow sand filtration, and sterilization with liquid chlorine, so that a superior quality of water is delivered to the people.

The water intakes on the Schuylkill are protected from sewage pollution from Philadelphia by the separate system of sewers and intercepting sewer mentioned before. The Torresdale intake is unprotected save by the Pennypack Creek sewage treatment works. Fortunately, the population adjacent to this intake is scattered, and only a few sewers exist for several miles below the intake.

*The Problem of Sewage Disposal.* — The conditions being as described, it is evident that the problem of sewage disposal confronting the city of Philadelphia consists in:

Protection of the source of the water supply taken from the Delaware River at Torresdale;

Restoration of the streams which are now polluted by sewage to a clean condition, and their permanent maintenance in that condition, together with means for prevention of future sewage pollution of streams now clean;

Improvement of the port by cleansing the docks now sludged up and providing against future sewage pollution of them, and maintenance of the water of the Delaware River in a sufficiently clean condition that there will be no danger of nuisance even during extreme droughts in summer.

Because of the large area involved and the importance of obtaining practical results from funds as they may be appropriated in allotments of a few millions, the successful solution of the sewage disposal problem in Philadelphia is dependent mainly upon the system of intercepting sewers adopted.

For example, one of the plans investigated in the preliminary studies was the collection of all the sewage of the city to a point on the Delaware River below the mouth of the Schuylkill River and positively below any possible influence upon the Torresdale water intake, so as to reduce to a minimum the degree of treatment of the sewage.

This plan was rejected because no protection from nearby pollution was afforded the Torresdale intake until there would have been completed the intercepting sewer along the Delaware River from the mouth of the Schuylkill River.

The cost of this sewer, with its appurtenant siphon and pumping stations, would amount to $22 000 000, which is only $400 000 less than the estimated cost of the entire plan which was adopted.

## The Adopted Plan.

The comprehensive plan for the collection, treatment and disposal of the sewage of Philadelphia, recommended in the report published in 1915 and subsequently approved by the Pennsylvania State Department of Health, provides for the division of the city into three main sewerage areas, known as the Northeast, Southeast and Southwest divisions, each to be provided with a system of intercepting sewers to conduct the dry weather flow of sewage and first flush of rainfall to sites on the bank of the Delaware River.

*The Three Divisions.* — The Northeast division is that part of the city northeast of a line beginning on the Delaware River at Port Richmond and extending to and along the Wissahickon Creek. Its estimated population in 1950 is 1 100 000 and the treatment works will be designed for a daily flow of 208 000 000 gals.

The Southwest division is that part of the city included in the watersheds of the Schuylkill River, the southwest side of Wissahickon Creek, the northeast side of Cobbs Creek and that part of the Delaware River watershed having sewer outlets between Port Richmond and Market Street. The estimates indicate that in 1950 1 663 000 people will dwell in this division and will produce 417 000 000 gals. of sewage a day.

The Southeast division is that part of the Delaware River watershed south of Market Street and east of Broad Street. The estimates indicate that a population in 1950 of 390 000 in this division will produce 82 000 000 gals. of sewage a day. The Southeast division is quite flat and will be provided with only a single intercepting sewer approximately parallel with the Delaware River.

*High and Low Level Intercepting Sewers.* — Comparative estimates showed that in the case of the Northeast and Southwest divisions, which include high land, economy would be secured even by an increased cost of the construction of the sewers by building them at two levels to minimize the annual charges for pumping by delivering to the works by gravity the sewage from the high land.

This principle is shown in the design of the intercepting system for the Southwest division, in which a main gravity intercepting sewer extends about 11½ miles from the site of the Southwest works to a terminus northeast of the center of the city. Grades along the lower part as low as .02 ft. per 100 are made possible by adding to the sewage directly collected by gravity as much sewage as possible collected by low-level intercepting sewers and raised by pumping to the main gravity flow to increase its volume as much as possible.

*Degree of Treatment.* — The plan recommended in the report issued in 1915 involves the use of coarse screens and grit chambers for all three treatment works, to be followed by sedimentation and sludge digestion in Emscher tanks at the Northeast and Southwest works and by fine screening at the Southeast works, where, in comparison with the other two plants, a relatively small quantity of sewage will be received and which will be located in a part of the city expected to develop into a great industrial section where a more extensive treatment works is impractical.

The tanks at the Northeast works have been planned to be built at such an elevation that their effluent can be applied to percolating filters in the future when the protection to the source of the water supply will require more refined treatment than only the removal of the settleable solids.

It was recognized that processes of sewage treatment, especially oxidation, are being improved very rapidly, and it was thought that these improvements will surely allow of less loss in head and area than are required for percolating filters; therefore ample land and head are provided for the future.

In the case of the Southwest works, the effluent of which will have no effect upon the water supply of the city, estimates of cost showed it to be economical to place the tanks at an elevation just high enough for a gravity discharge to the river, and if, in the future, more refined treatment should be required, it will then be necessary to pump the tank effluent to the required elevation.

*Disposal.* — At all three works the effluent will be discharged through submerged outlets in the channel of the Delaware River in such a way as to insure its mingling with the great tidal flow of the river and thus utilize to the highest possibility its great diluting and oxidizing power. Sludge can be used for filling low land adjacent to the Northeast and Southwest works, and screenings will be incinerated at the Southeast works.

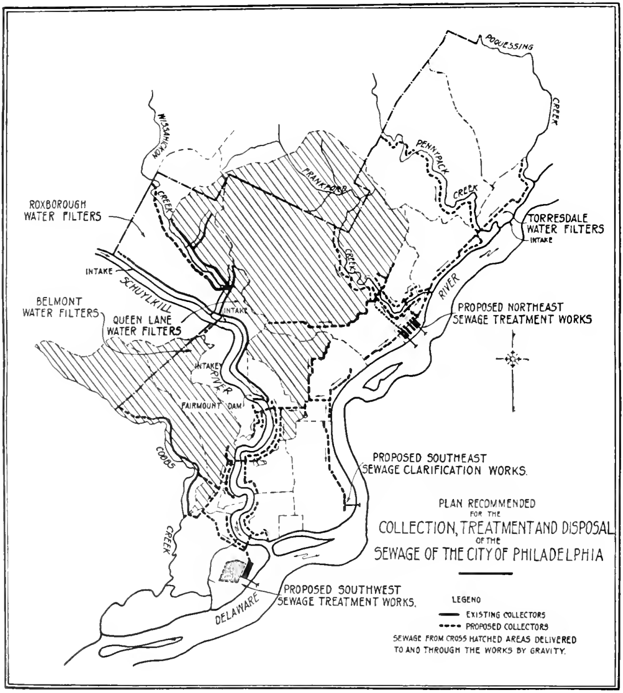
This use of the Delaware River for the ultimate purification of the sewage is in recognition of the fact that modern life in large cities has placed so many demands upon available funds that natural resources must be utilized to the fullest extent compatible with good sanitation, and the cost for construction and operation of artificial sewage treatment works kept at a minimum.

## The Northeast Division.

As the Northeast division of the city is nearest the source of water supply at Torresdale, the first funds appropriated for sewage disposal will naturally be expended there, and hence a brief description of the collecting system for this division is of interest.

*Separate System Sewers.* — On the drainage areas tributary to the Delaware River over four miles below Poquessing Creek, the separate system of sewers will be installed and also connections made from the storm water sewers to the intercepting sewers to collect the first flush of rain water. This will protect the river for two miles above and two miles below the intake of the Torresdale water filters from the discharge of any sewage from Philadelphia even during rainstorms.

The entire watershed of Pennypack Creek will be furnished with the separate system of sewers, as both banks of this creek will be a park and the creek enters the Delaware River 2 000 ft. below the Torresdale water intake. In addition, those portions of drainage areas between the intercepting sewers and the bank of the Delaware River will be supplied with separate sewage sewers laid to drain from the river toward the intercepting sewers, while the rain water will be carried in the storm water outlets of the combined sewers draining this part of the division.




*Combined Sewers.* — The remainder of this division will be sewered on the combined system, which is already installed over a large part of it, and the dry-weather flow and first flush of rainfall will be admitted to the intercepting sewers.

*The Intercepting Sewers.* — From the site of the Northeast works an intercepting sewer will be constructed approximately parallel to the Delaware River terminating at Poquessing Creek, which is the present northern boundary of the city. Into it will drain by gravity the low-level intercepting sewers to be constructed along the banks of the Frankford Creek and an intercepting sewer collecting sewage from the drainage area of Pennypack Creek.

The present Pennypack Creek works will be abandoned and the sewage now treated there will be pumped into the upper Delaware intercepting sewer and conveyed to the Northeast works.

Another low-level intercepting sewer will extend southerly from the Northeast works for about 1½ miles and carry upstream to the works sewage tributary to the Delaware River below the high-level intercepting sewer, which will be about 2 miles back from the river.

The sewage collected by these systems of low-level sewers will amount to 85 000 000 gals. a day in 1950, and will have to be pumped to pass through the treatment works.

Sewage from the western part of the Northeast division will be collected by two high-level intercepting sewers, one to be constructed across the city in an easterly direction to collect sewage normally flowing south and convey it to a point about two miles northwest of the site of the Northeast treatment works, the other to extend practically along the bank of Frankford Creek from county line to the terminus of the other high-level intercepting sewer. In 1950 these two sewers will deliver 120 000 000 gals. of sewage a day to a grit chamber, from which the sewage will be carried down a ridge street to the site of the Northeast works in conduits designed to act as an inverted siphon 7 000 ft. long. To meet the varying quantities as the general sewer system is extended and to maintain self-cleansing velocities and obtain the flattest possible hydraulic grade line to reduce losses in head, the complete installation will consist of 66-in., 78-in. and 90-in. tubes. These will deliver the high-level sewage to elevation —15 at the works. But if the blow-off gates at the lower end are open, the two smaller tubes will carry all the high-level sewage with the hydraulic grade line lying within the tubes to elevation —6.5, which is sufficiently high to provide fall through a works consisting only of tankage.

## The Frankford Creek High-Level Intercepting Sewer.

Subsequent to the issuance of the Report on Sewage Disposal, Councils of Philadelphia appropriated $500 000 and authorized the construction of the Frankford Creek high-level intercepting sewer from the Delaware River nearly to the county line. This work is partly designed in detail, and about a mile of sewer is now under contract.

A description of the important features of this sewer and its appurtenances will indicate most of the principles upon which the project for the entire city is based.

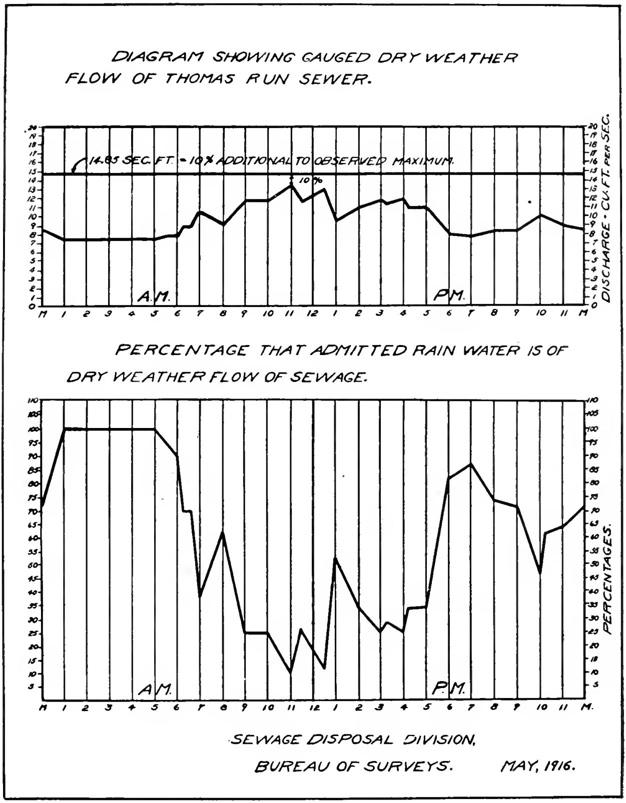
*Determining Sizes of Intercepting Sewers.* — To determine sizes of the intercepting sewers and treatment works for the whole city, the first requirements were estimates of the quantities of sewage to be collected both at present and in 1950. Gagings were, therefore, made of the dry-weather flow in several sewers draining characteristic areas, and, from studies of distribution and growth of population, estimates were made of the population contributing to the gaged sewers and also of the 1910 and 1950 estimates of population on each existing and proposed drainage area in the city above the point where the intercepting sewer would collect the sewage.

From these data, average flows per capita for different kinds of areas were determined and applied to the ungaged sewer areas.

From a study of these gagings it was also determined that in the larger sewers the daily maximum rate of flow would be 128 per cent. of the average.

It was decided to admit to the intercepting sewers the first flush of rain water to a minimum amount equal to 10 per cent. of the daily maximum rate of dry-weather flow. This makes what will be called "storm maximum flow" equal to 141 per cent. of the average dry-weather flow.

In consideration of the fact that storms are as likely to occur at times of daily minimum flow as at the maximum, an examination of certain gagings showed that on an average this decision




meant that an amount of rain water equal to 55 per cent. of the dry-weather flow will be admitted to the intercepting sewers. A study of certain drainage areas indicates that this amount of rain water represents storms of an intensity of .013 in. per hour.

The records of the United States Weather Bureau showed that in Philadelphia about 700 rainy hours can be expected a year, and of these, during 350 hours, storms of .01 in. per hour or less may be anticipated. In other words, the decision to admit 10 per cent. rain water in addition to the maximum dry-weather flow provides on the average for no overflow of sewage to the streams during about one half the rainy hours of the year.

The intercepting sewers were designed to carry the "storm maximum flow," or 141 per cent. of the 1950 estimated average flow, at three-fourths capacity, which in circular sewers is at two-thirds depth.

The hydraulic grade line of the estimated 1950 storm maximum flow was used in designing these sewers, which were then examined for self-cleaning velocities using the invert grade and the 1910 daily minimum flow.

*The Upper Part of the Sewer.* — The Frankford Creek high-level intercepting sewer begins at the county line as a 3-ft. sewer, which is large enough to receive the sewage of 55 000 persons from the adjoining county if the boundaries of the city are extended in the future. It will be constructed along the bank of Tacony Creek through park property for a distance of about three miles to the mouth of Wingohocking Creek, where it will be 5 ft. in diameter. The capacity of this sewer provides for the admission of 200 per cent. of the 1950 average flows in order to afford more adequate protection to the creek through the park.

The Wingohocking Creek at this point now carries the drainage of Germantown (a section of Philadelphia), discharged into it from a 19.5-ft. combined sewer which will be extended to the mouth of the creek in the future.

It is planned to construct the invert of the outlet portion of the future combined sewer, deflect the creek into it, and divert the dry-weather flow into the intercepting sewer, allowing the storm flows to pass to the creek.

This will be one of the largest sewers in Philadelphia to be connected to an intercepting sewer, but the principles involved in the construction are common to nearly all the points of interception.

*Method of Interception.* — It is common practice to place intercepting sewers entirely beneath combined sewers and to admit the sewage to the intercepting sewer either through a slot or by a weir or through a gate controlled by a float which is actuated by the height of water either in the combined sewer or in the intercepting sewer.

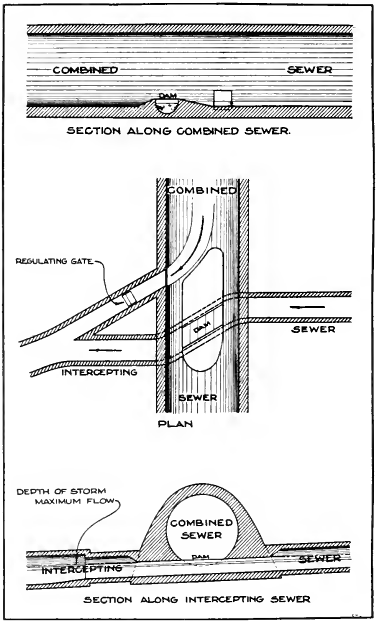
In such construction there is a considerable loss in head, and when only a slot is used, there is no control of the amount of rain water admitted to the intercepting sewer when storm water fills the combined sewer. The complicated mechanism of the float-controlled valves is also a cause of trouble, and requires considerable expenditure for maintenance.

To overcome these difficulties, a new design has been made, consisting of a combination of the intercepting device used in Dresden, Germany, and a regulating gate without any float control designed by one of the engineers of the Bureau of Surveys in Philadelphia.

The maximum hydraulic grade line in the intercepting sewer is fixed at the point of interception at or as near below as possible to the 1950 estimated " storm maximum " elevation of water surface in the combined sewer. This means that generally the intercepting sewer passes through the combined sewer. It will be recalled that the intercepting sewers are designed so that " storm maximum flows " are at three-fourths capacity or in circular sections at two-thirds depth. The one-third air space in the intercepting sewer is discontinued as the intercepting sewer is carried through the combined sewer, and the top of the intercepting sewer is constructed of cast-iron plates which form the crest of a dam in the invert of the combined sewer. It will be noted that the crest of this dam is at the elevation of " storm maximum " flow in the combined sewer, and hence serves to hold back all flows of less than that amount.

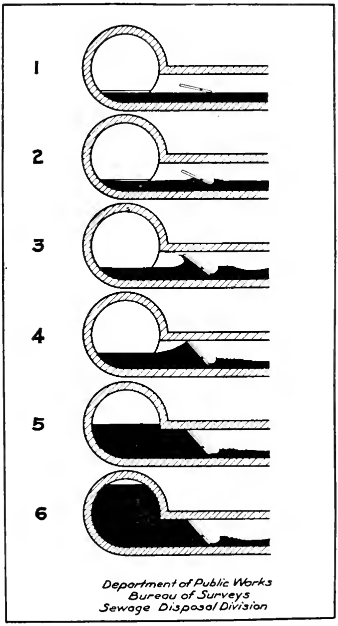
In the side of the combined sewer and upstream from the dam a rectangular opening is made to carry the dry-weather sewage flow and such portion of storm water as predetermined to the intercepting sewer.

In this rectangular conduit, between the combined sewer and the intercepting sewer, there is placed the regulating device, which consists of a structural steel rectangular leaf, supported below its center by a horizontal shaft. The natural tendency of




the leaf is to rest against stops in a nearly horizontal position, due to the fact that the center of gravity of the leaf is above the point of support.

The horizontal shaft is placed at about the same elevation as the crest of the dam in the combined sewer, and consequently all flows below this elevation pass freely under the regulator into the intercepting sewer. When storm water increases the depth of flow to an elevation above the horizontal shaft, the lower part of the leaf offers resistance to the free flow and causes the water to rise in back of the gate, which increases the pressure upon the upper part and causes the gate to begin to close. The rate of




closure depends upon the velocity of approach to the gate and to the height of water beyond the gate.

In its closed position the upper part of the gate bears against the top of the rectangular conduit, but the lower part of the gate is designed to clear the bottom of the conduit by an amount sufficient to leave an opening beneath, so that when the combined sewer runs full, the head upon the opening will cause a discharge under the regulator equal to the average dry-weather flow. This allows a velocity in front of the gate to keep grit in the storm water moving forward, instead of settling in the approach to the gate.

When the flow in the combined sewer abates to an elevation where the hydrostatic pressure on the upper part of the gate is less than upon the lower part, the natural tendency of the regulator causes it to open and the normal flows are resumed to the intercepting sewer.

*The Lower Part of the Sewer.* — To resume the description of the Frankford Creek high-level intercepting sewer, after the dry-weather flow has been diverted into the sewer by the device described above, it will be conveyed for nearly a mile through an 8.5-ft. semi-elliptical concrete sewer (now under contract) along the most direct route, which requires three tunnels to the point where the central Delaware high-level intercepting sewer mentioned before will join it. Here an entire block of ground about 580 ft. square, upon which to erect a grit chamber, has been condemned.

It will be recalled that the Frankford Creek intercepting sewer above this point is designed to carry a storm maximum flow of 200 per cent. of the average flow, whereas the treatment works will have a normal maximum capacity of only 141 per cent. of the average. The reduction in quantity will be effected just before the sewage enters the grit chamber by constructing an overflow chamber, one side of which will consist of a dam whose elevation wi l be placed at the proper elevation to allow 141 per cent. of the average flow to pass on, while the excess flows on to a sewer discharging into Frankford Creek at a point below the Park.

The grit chamber will be provided at its entrance with a set of bulb bars spaced about 10 or 12 ins. apart to restrain large objects which should not, but may, gain entrance to the intercepting sewer. It will be designed with a capacity of 170 000 000 gals. a day, which is its 1950 estimated storm maximum rate. It will consist of three cells, each about 100 ft. long, 18 ft. wide and, at maximum flow, 6 ft. deep. The cross section is a rectangle with the two lower corners cut off at 45 degrees, so that, as the depth of flow varies, the cross section in service will maintain velocities of about one foot per second. In order to do this, devices will be required at the outlet end of each cell to maintain the water surface at desired elevations. Studies have been made of a series of vanes having elongated, lozenged-shaped cross section and fastened to vertical shafts, which will be held in a frame sliding in grooves in the side of the effluent channels. When the shafts are set so that the longer edges of the vanes are parallel to each other, they will offer but little resistance to the flow of sewage. By the turn of a handle at the top, however, the vanes can be placed so as to offer any amount of resistance up to complete closure.

It is planned that the grit chambers will be constantly in service, which requires grit removal without unwatering a cell. Several devices have been studied, such as conveyors and water ejectors, and while, as yet, no definite decision has been made, it is most likely that a simple grab bucket operated from a crane will be used.

Contrary to the usually accepted idea, the deposit in this grit chamber is not expected to be clean sand and, as there is every indication that the neighborhood will be developed into a residential section, it is of the utmost importance to prevent any offense from bad odors. It is, therefore, planned to wash the deposit in a manner similar to that used in the Torresdale water filters and to provide storage bins from which the clean sand can be removed for use on the sludge drying beds at the Northeast works.

In connection with this grit chamber, several studies have been made of screens as a protection to the long inverted siphon between it and the works. In order to avoid the necessity of hauling away or incinerating the screenings, serious consideration is being given to installing inclined bar-screens with clear openings of about 2 ins. or 2½ ins., the screenings to be passed through crusher rolls to reduce them in size to less than the openings in the screens and then to discharge them into the grit chamber in front of the screens.

The effluent of the grit chamber will be carried for about 1 200 ft. to a valve chamber through a conduit, the invert of which will not be parallel to the arch. The arch will be made parallel to the 1950 storm maximum hydraulic grade line, and the invert grade will be made sufficient to cause self-cleansing velocities with the minimum flows from Wingohocking Creek when the sewer is first placed in service.

At the lower end of this sewer the storm maximum hydraulic grade line approaches the street surface, and, as has been stated before, in order to conserve the potential energy in the sewage from the high land, the principle of the inverted syphon will be utilized for about 7 000 ft. to the site of the Northeast works.

The head of the pressure tubes will consist of an underground chamber containing three sluice gates controlling entry to the 66-in., 78-in. and 90-in. tubes. At first only the 66-in. tube will be built, as it has ample capacity as a sewer to carry to the Delaware River the sewage to be intercepted by the present construction. The lower end of the siphon tubes will be provided, when it is desired to discharge sewage to the high tank elevations, with turn-up tubes and blow-off gates to induce scouring velocities.

## Future Appropriations.

On May 16 last, two loan bills to provide $115 000 000 for municipal improvements were favorably voted upon by the citizens of Philadelphia. This sum includes $3 200 000 for sewage disposal, toward acquisition of land, for the construction of the intercepting sewers and the treatment works for the Frankford Creek drainage area.

Philadelphia looks forward to the actual realization of this plan, which has been under investigation and study since 1907, and the hope is that the results accomplished by the expenditure of these funds will demonstrate the advisability of carrying out the entire scheme which is a solution of the sewage disposal problem now confronting the city of Philadelphia.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

# A METHOD OF TRANSFORMING LATITUDE AND LONGITUDE INTO PLANE CO-ORDINATES.

By Sturgis H. Thorndike,* Member Boston Society of Civil Engineers.

This article will scarcely be of general use or interest to engineers. Occasionally, however, any engineer may find it highly important to obtain the location in plane coördinates of a group of points whose latitude and longitude he knows. The following simple and accurate method of transformation may then be the means of saving gray-matter, time and money for him, as it has been in the experience of the writer.

Many engineers, who are constantly using plane cöordinates, hesitate a little to utilize in connection with them determinations by latitude and longitude. They associate latitude and longitude with spherical excess, the *L M Z* formula, and other complications, and hardly care to take the time to study up processes which they have not used since they left college, and to make sure that they still understand them.

There is a certain sound basis for this hesitation, since it is a fundamental impossibility to represent a spherical surface accurately on a plane surface; the best possible method gives merely an approximation, and the inaccuracies become greater

Note. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before November 10, 1916, for publication in a subsequent number of the Journal.

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and greater as the distance from the center of the system is increased. However, within a circular area of 12 miles radius, the spherical surface of the earth can be represented on a plane with an error of less than 0.15 ft. at the circumference, and at a 24-mile radius this error still does not reach 1.25 ft.

Whatever method of transformation is used, the origin should preferably be chosen near the center of the area involved; if it is located at one corner, or outside the area, this unavoidable "spherical" error will be unnecessarily large at the diagonally

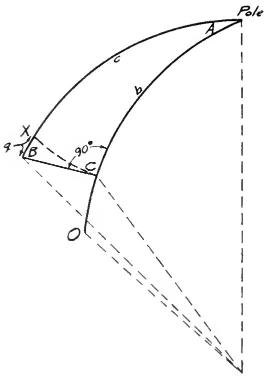


FIG. 1.
(Spherical Surface.)

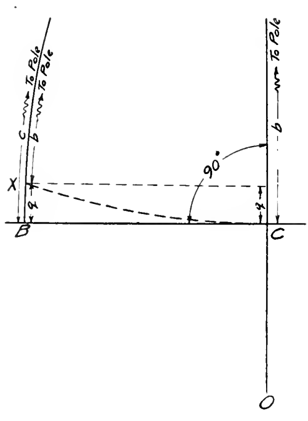


FIG. 2.
(Plane Surface.)

opposite corner and may become troublesome. But the plane coördinates can still be kept all of the "plus" sign by giving to the coördinates of the origin a large numerical value. In Boston, the State House is taken as the origin, and all coördinates are calculated from its meridian as an axis; but the coördinates of the State House are frequently assumed as 50 000 ft. N. and 50 000 W., so that there are no "minus" values within the city limits.

The method described below requires no understanding of spherical trigonometry except the simplest application of the spherical right triangle. Although it involves approximations, the effect of these is hardly noticeable as distinct from the inevitable "spherical" error alluded to in the preceding paragraphs. In Massachusetts, the method gives, at a distance of four or five miles from the meridian of the origin, a determination of position differing by less than 0.1 ft. from that given by the usual but cumbersome "$L\ M\ Z$ method" (inverse solution).

*Required*, the plane coördinates of the point $X$ whose latitude and longitude are known.

In Figs. 1 and 2, let $O$ be the origin of the system of plane coördinates, the latitude and longitude of $O$ being known.

Let $CO$ be a portion of the meridian through $O$; i. e., the north-and-south or vertical axis of the coördinate system.

Let $XC$ be a portion of the parallel of latitude passing through the point $X$; the distance from $X$ to the pole, or from $C$ to the pole, is the co-latitude of the point.

At $C$, erect a perpendicular to the vertical axis; on a sphere this is a portion of a great circle, from which the parallel $XC$ will diverge by an amount $q$ at the point $X$.

Using approximations, which can be shown to be quite negligible, the plane coördinates of $X$ are at once seen to be (Fig. 2):

(1) Westing $= CB$; this is the difference in longitude, $A$, between the meridian of the origin and the meridian through $X$, reduced from angular measurement (in seconds) to linear measurement.

(2) Northing $= OC + q$; this is the difference in latitude between the point and the origin, corrected by the divergence $q$ and reduced from angular measurement (in seconds) to linear measurement. If $C$ lies south of $O$, $q$ must be subtracted from $OC$.

It is convenient to keep the discussion and calculations in angular measurement, seconds, making the final transformation into linear measurement the last step of all.

The distances $OC$ and $CB$ are already known in angular units. The determination of the only remaining distance, $q = BX$, is very simple, and is as follows:

In Fig. 1 is shown the right spherical triangle having the angle of 90° at the point $C$.

$b$ is the co-latitude of the point $X$.

$c$ is equal to $b$ plus the divergence $q$.

*Required*, the value of $q$.

$\cos A = \frac{\tan b}{\tan c}$ (spherical right triangle; the only spherical formula required).

$\frac{\tan c}{\tan b} = \frac{1}{\cos A}$.

$\log \tan c - \log \tan b = \text{colog} \cos A$.

Since $c$ differs from $b$ by $q$ seconds, log tan $c$ will differ from log tan $b$ by $q$ times the tabular difference for one second in the table of logarithmic tangents at angle $b$. That is, $\log \tan c - \log \tan b = q \times \text{tab diff}$.

Then, also, $\text{colog} \cos A = q \times \text{tab diff}$, and finally $q = \frac{\text{colog} \cos A}{\text{tab diff}}$.

That is, to find any value of $q$ in seconds, it is merely necessary to *divide the colog cos A by the proper tabular difference.*

Where a number of neighboring points are to be transformed from spherical into plane coördinates, the most convenient process is to select a central latitude and there plot a curve showing corresponding values of, (1) difference in longitude, $A$, and, (2) divergence, $q$; Fig. 3 is such a plot, values of $q$ being calculated and plotted at intervals of 30 sec. in value of $A$. The divergences have such small values and the tabular difference changes so slightly within the few minutes of latitude usually covered that this one curve may generally be utilized throughout the system, and from it the value of $q$ for any required point can readily be read.

In Table 1, the second column shows the value of the colog cosines for angle $A$ each 30 sec. from 0° to 0° 15′. These same values are used at whatever latitude a curve is to be plotted, and it may be convenient to have them at hand instead of hunting up a logarithmic table carried to the ten places desirable to give accuracy.

The third column of Table 1 shows divergences at latitude 42° 6′, the center of Springfield, Mass. In this case, each colog cos was divided by .0000042327, the tabular difference in logarithmic tangents at 47° 54′ (the co-latitude).

Fig. 3, a plot of these divergences, is really the parallel 42° 6′ plotted on a plane to a much-distorted scale. In practice, it might be well to make this diagram on a larger scale than shown.

In transforming the distance *CB* from seconds into linear units, the linear equivalent of a second of longitude at the

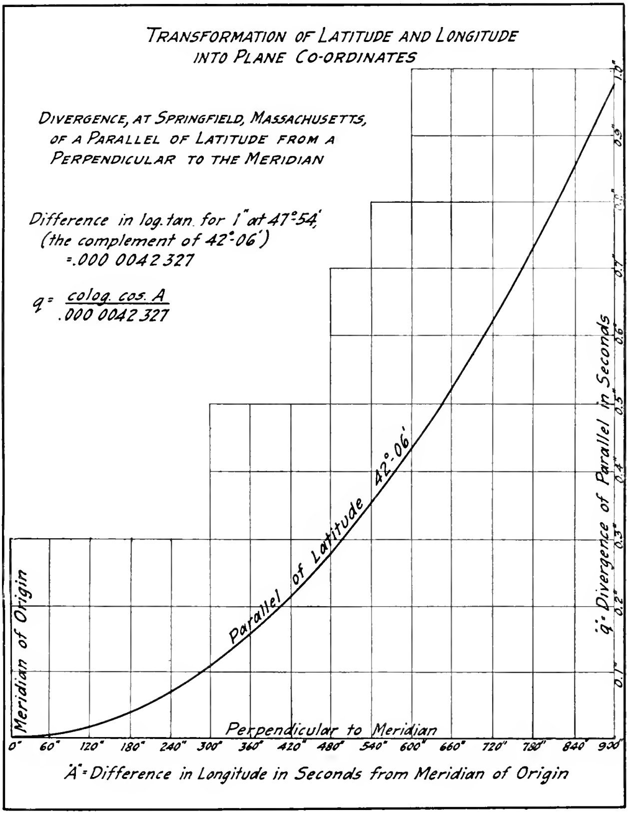


FIG. 3.

latitude of *X* should be used. In transforming the distance $OC+q$ from seconds into linear units, the linear equivalent of a second of latitude at the mean latitude of $X$ and $O$ should be used. The most convenient place to obtain these equivalents is from the constants $A$ and $B$ of the $L\ M\ Z$ formula as published by the United States Coast and Geodetic Survey in the Superintendent's reports for 1894 and 1901, and in "Special Publication No. 8," published in 1911. These constants are also given in "Geographic Tables and Formulas," compiled in 1904 by Samuel C. Gannett, of the United States Geological Survey.

$$1'' \text{ longitude} = \frac{1}{A} \cos \text{lat.}$$

$$1'' \text{ latitude} = \frac{1}{B}.$$

The linear equivalents of angles of latitude and of longitude are also tabulated in "Tables for a Polyconic Projection of Maps," third edition, Special Publications No. 5, 1910, Department of Commerce and Labor, United States Coast and Geodetic Survey. In these tables, however, the equivalents are not carried to enough significant figures to give the accuracy usually required in coördinate calculations.

This article and the equivalents referred to in the preceding paragraph furnish all that is necessary to utilize latitude and longitude determinations in any system of plane coördinates. To utilize to the full the refinement given by the values of colog cos $A$ in column 2, Table 1, the tabular difference for 1′ in log cotan at the central latitude might be carried to ten places instead of the usual seven places, but this will seldom be necessary.

The latitude and longitude of a point are seldom determined to greater refinement than .001 sec., roughly, $\frac{1}{10}$ ft. As it is of no avail to carry the refinement in the reduction formula further than the accuracy of the original data, the method just described has, therefore, a precision greater than can usually be utilized.

## Summary.

The easting (or westing) of a point is the difference in longitude from the meridian of the origin, reduced to linear measure at the latitude of the point.

The northing (or southing) of a point is its difference in latitude from the origin, corrected by the divergence of its parallel of latitude from a perpendicular to the meridian of the origin, and reduced to linear measure at the mean latitude of point and origin.

## TABLE I.

DIVERGENCES AT SPRINGFIELD, MASS., OF A PARALLEL OF LATITUDE FROM A PERPENDICULAR TO THE MERIDIAN.

The tabular difference for one second in the table of logarithmic tangents is .0000042327 at the tangent of 47° 54′, the co-latitude of the center of Springfield.

Divergences are stated in seconds of latitude.

| Angle $A$ = Diff. in Long. | Colog Cos $A$. | Divergence $q = \frac{\text{Colog Cos } A}{.0000042327}$. |
|---|---|---|
| 0° 00′ 30″ | .000 0000 046 | 00.00109″ |
| 01 00 | 00 184 | .00435 |
| 01 30 | 00 414 | .00978 |
| 02 00 | 00 735 | .01736 |
| 02 30 | 01 149 | .02715 |
| 03 00 | 01 654 | .03908 |
| 03 30 | 02 251 | .05318 |
| 04 00 | 02 940 | .06946 |
| 04 30 | 03 721 | .08791 |
| 05 00 | 04 594 | .10854 |
| 05 30 | 05 559 | .13133 |
| 06 00 | 06 615 | .15628 |
| 06 30 | 07 764 | .18343 |
| 07 00 | 09 004 | .21272 |
| 07 30 | 10 336 | .24419 |
| 08 00 | 11 760 | .27784 |
| 08 30 | 13 275 | .31363 |
| 09 00 | 14 883 | .35162 |
| 09 30 | 16 583 | .39178 |
| 10 00 | 18 374 | .43409 |
| 10 30 | 20 258 | .47860 |
| 11 00 | 22 233 | .52527 |
| 11 30 | 24 300 | .57410 |
| 12 00 | 26 459 | .62511 |
| 12 30 | 28 710 | .67829 |
| 13 00 | 31 053 | .73364 |
| 13 30 | 33 488 | .79117 |
| 14 00 | 36 014 | .85085 |
| 14 30 | 38 633 | .91272 |
| 15 00 | 41 342 | .97672 |

## DISCUSSION.

George L. Hosmer.* — The method of calculating plane coördinates described by Mr. Thorndike was devised by him in 1898 and employed to calculate, from the known latitudes and longitudes, the coördinates of the corners in the boundary lines and harbor lines surrounding the city of Boston. When comparing the results obtained by this method with those found by the so-called *L M Z* formulas it was noticed that there was a very small but apparently systematic difference between the two. Mr. Thorndike's results invariably placed the triangulation points a few hundredths of a foot south of the positions assigned by the *L M Z* formula. Recently, in connection with the calculation of plane coördinates in the city of Springfield by the two methods, the question again arose as to the cause of the discrepancy. The following discussion is the result of a study to ascertain the true relation of the two formulas.

Before investigating the errors of the formulas themselves it is desirable to determine the errors arising from the assumption that a spherical surface may be represented on a plane.

### Errors of a Plane-Coördinate System.

In order to investigate the error involved in surveying on the surface of a sphere of the size of the earth and then computing the results on the assumption that the surface is a plane, let us suppose that the plane on which the computations are to be made is tangent to the sphere at a point *O*, and that a point *A* on the surface of the sphere is defined as lying N 45° W from *O* and at a distance of 20 000 meters (about 12 miles) measured on a great circle. Denote this path from *O* to *A* as "Route 1." By solving the spherical right triangle, using a radius corresponding to the mean curvature in latitude 42°, we find that if a traverse be run due north 14 142.159 m. and then, turning 90°, run westerly 14 142.124 m. on a great circle, without any errors in the measurements, this traverse will terminate exactly at point *A* on the spherical surface (Route 2). If, now, the coördi-

* Member Boston Society of Civil Engineers.

nates of $A'$ on the plane be computed by the routes mentioned, we find for these coördinates —

| | $x$ | $y$ |
|---|---|---|
| Route 1 | 14 142.136 m. | 14 142.136 m. |
| Route 2 | 14 142.124 | 14 142.159 |
| Difference | −.012 | +.023 |

This shows that in passing from $O$ to $A$ by Route 2 we place point $A'$ about .02 m. north and about .01 m. east of the position

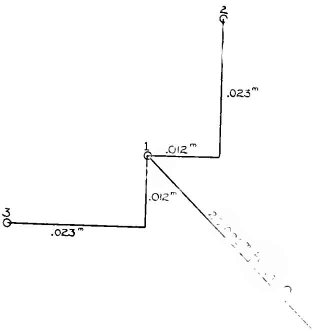


FIG. 4.

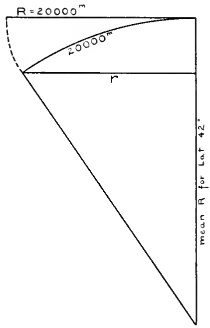


FIG. 5.

found by Route 1. A similar traverse (Route 3) running westerly on a great circle perpendicular to the meridian of $O$, and then turning 90° and running northerly to $A$ would place $A'$ .02 m. west and .01 m. south of that found by Route 1. The relative positions of these three points are shown to scale in Fig. 4.

The extreme divergence of positions 2 and 3 is about .05 m., or about 2 in. This represents the error of closure which would be found in a traverse run from $O$ by Route 2 to $A$ and back by Route 3 to $O$, but computed as a plane traverse. It should be observed that the measurements themselves are supposed to be exact and that the closure of the field-work on the spherical surface is supposed to be perfect.

It is interesting in this connection to note that the length of the circumference of a circle having a radius $R = 20\,000$ m. exceeds the length of the circumference of a circle whose radius ($r$) is the sine corresponding to an arc of 20 000 m. by about 0.21 m. (Fig. 5). This is about four times the error shown in Fig. 4. This 0.21 m. represents, therefore, the total amount of stretching that would occur at the outer edges of the spherical segment if this portion of the sphere were forced to lie flat on the plane. It is also the discrepancy that would be found if a traverse were run around the circumference of our 12-mile circle, and its length compared with the length of the circumference as computed from its radius.

It should be observed that these errors are due entirely to the nature of the problem and have nothing to do with errors of measurement. It is obvious, however, that these errors are very small when compared with the errors of measurement of even very high-grade field-work. In deciding whether any formula is an appropriate one for making these calculations, our judgment will naturally be influenced by the fact that these spherical errors are bound to enter the results, as well as by the simplicity of the formula itself and by a consideration of the magnitude of the errors which are admissible in good field-work.

## Methods of Calculating Plane Coördinates.

In calculating plane coördinates from the given spherical coördinates, we have a choice of these three methods. First, we may use, in its customary form, the "inverse" solution of the $L$ $M$ $Z$ formulas, the two points being the origin and the triangular point whose plane coördinates are desired. Second, we may modify this solution, as was done in the city of Springfield, as follows: The $x$ coördinate is found by converting into feet the difference in longitude between the origin and the given point; the $y$ coördinate is found by converting into feet the difference in latitude, taking factor $B$ for the middle latitude, and then increasing or decreasing this distance by the amount in feet of the offset from the great circle to the parallel as found by the expression $\frac{\tan \phi}{2N} \cdot x^2$, which is obtained directly from the $L\ M\ Z$ formula for difference in latitude when the azimuth is taken as 90°; for convenience we shall refer to these as the "Springfield formulas." Third, we may use the method described by Mr. Thorndike.

## Error in the Assumption that $x$ Equals the Difference in Longitude in Linear Units.

A computation of the difference in length of the $x$ coördinate and the actual arc of the parallel for the case already discussed (latitude 42°) shows it to be but .002+ m., which is insignificant in comparison with the inevitable spherical errors already mentioned.

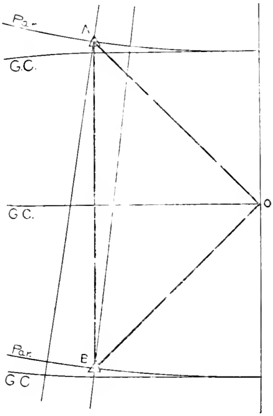


Fig. 6.

## Error in $y$ of the Springfield Formula.

($A$) *When Corrections are made at the Parallel of $A$.*

In order to compare these methods let us suppose that a second point $B$ (Fig. 6) is located S 45° W from $O$ at a distance of 20 000 m. If we calculate the geodetic coördinates of $A$ and $B$ by the $L\ M\ Z$ formulas and then calculate the length of $AB$ by an inverse solution, we obtain 28 284.25 m. This agrees with the actual meridian arc in meters, after allowing for the inclination of $AB$ to the meridian of $A$. This length is .02 m. shorter than the plane distance (28 284.27), as it should be according to Fig. 4.

If we calculate the coördinates of $A$ and $B$ by applying the correction $\frac{\tan \phi}{2N} \cdot x^2$ at the parallels of $A$ and $B$, and then compute the distance $AB$, we obtain 28 284.33 m. This result exceeds the plane distance by .06 m., owing largely to the fact that we have assumed that the two great circles through $A$ and $B$, perpendicular to the meridian of $O$, are parallel to each other, whereas they really converge about .05 m. (Fig. 6).

### (*B*) *When Corrections are made at the Parallel of O.*

If we apply this correction as found for the latitude of $O$, we obtain for $AB$ the distance 28 284.20 m. This is too short by .05 m. because no allowance has been made for the inclination of $AB$ to the meridian of $A$ (Fig. 6).

The true value lies between these two results. If the correction were calculated for the middle latitude of $OA$ (and of $OB$), the resulting length would check the plane distance closely and would be much nearer the true distance than either of the others. In the $L\ M\ Z$ formulas these errors are taken care of by the addition of the "$E$" term.

## Error in $y$ of Thorndike's Formula.

The length of $AB$ as found by Thorndike's formula, for the latitudes of $A$ and $B$, is 28 284.32 m., which checks (within .01 m.) that found by the Springfield formulas applied to the parallels of $A$ and $B$. Although the length of $AB$ checks the Springfield results, the $y$ coördinates themselves for $A$ and $B$ place each point about .06 m. south of the position given by the Springfield formulas, as shown in the table below.

| | y Coördinates of A. | | y Coördinates of B. | |
|---|---|---|---|---|
| Plane | N | 14 142.14 | S | 14 142.14 |
| Springfield, parallel of A | N | 14 142.16 | (parallel of B) S | 14 142.17 |
| Springfield, parallel of O | N | 14 142.10 | S | 14 142.10 |
| Thorndike | N | 14 142.10 | S | 14 142.22 |

In order to compare Thorndike's formula with the *L M Z* formula, we may expand the numerator, log sec *diff. long.* ($\Delta\lambda$), in series, from which we obtain

$$\log \sec \Delta\lambda = \log\left[1+\left(\frac{\Delta\lambda^2}{2}+\frac{5}{24}\Delta\lambda^4\right)+\cdots\right]$$

$$= \log_{10}e\left[\left(\frac{\Delta\lambda^2}{2}+\frac{5}{24}\Delta\lambda^4\right)-\frac{1}{2}\frac{\Delta\lambda}{4}+\cdots\right]$$

$$= \log_{10}e\left[\frac{\Delta\lambda^2}{2}+\frac{\Delta\lambda^4}{12}+\cdots\right]$$

Differentiating log tan *b*, or log cot $\phi$, to obtain an expression equivalent to "tab. diff. for one second," the denominator of his formula, there results

$$\frac{d\,(\log \cot \phi)}{d\phi} = \log_{10}e\,\frac{csc^2\phi}{\cot\phi}\cdot\sin 1'',$$

$$= \frac{\log_{10}e\cdot\sin 1''}{\sin\phi\cos\phi},$$

in which $\phi$ is the latitude and $d\phi$ is in seconds. The second term in the expression for log sec $\Delta\lambda$ is found to be negligible, hence

$$q = \frac{\left(\frac{\Delta\lambda^2}{2}+\cdots\right)}{\sin 1''}\cdot\sin\phi\cos\phi;$$

and since, from the *L M Z* formula,

$$s \sin \alpha = x = \Delta\lambda \cos\phi\; N \sin 1'',$$

therefore,
$$q = \frac{\tan\phi}{2N^2\sin 1''}\,x^2,$$

$$= \frac{\tan \phi}{2NR \sin 1''} x^2 \left(\frac{R}{N}\right),$$

$$= Cx^2 \left(\frac{R}{N}\right), \text{ which is the "}C\text{" term of the}$$

*L M Z* formula, except that it contains the factor $\frac{R}{N}$. In this form it is evident that the only difference between Thorndike's formula and the *C* term of the *L M Z* formula is that the latter has been multiplied by $\frac{N}{R}$, where *N* is the normal and *R* is the radius of curvature of the meridian. This ratio is introduced into the *L M Z* formula for the difference in latitude in order to reduce the difference in latitude on the sphere of radius *N* to that corresponding to the actual curvature of the meridian at the given point.

## Conclusion.

It thus appears that the sole error of Thorndike's formula is due to employing too long a radius of curvature of the meridian when calculating the offset from the great circle to the parallel. This might have been inferred *a priori*, since his formula for the *offset* is derived from a spherical triangle, and, in order to preserve its simplicity, no change is made in this part of his formula to allow for the spheroidal form of the earth.

On account of its greater simplicity, Thorndike's formula commends itself to any one not perfectly familiar with the *L M Z* calculations. The error involved in its use is not much greater than the error which, from the very nature of the problem, is sure to enter the result, no matter what formula is used in calculating the coördinates. Neither is its error any greater than that of the Springfield formulas, unless special precaution is taken to allow for this latter error. Finally, its error is quite small when compared with the errors to be expected in the field-work. From these considerations it is clear that the formula is sufficiently accurate for the purpose for which it is intended.

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PAPERS AND DISCUSSIONS

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# DISCUSSION OF "PAN-AMERICAN USE OF THE METRIC SYSTEM."

By Messrs. Frederick Brooks, Robert Spurr Weston, Alfred W. Parker and Edward P. Adams.

Mr. Brooks.* — *Commercial Use of the Metric System is wanted, irrespective of Its Technical Applications* — To open the discussion, a few branches of business will be successively taken up, showing that, in commercial transactions, the buying and selling of goods, ancient, customary units of weight and measure have continued in general use, so that practically all our people have failed to enjoy the advantages of the metric system in domestic trade, whereas in a wide range of technical and scientific work the metric system is established, so that the skilled few in factories and laboratories are partially obtaining benefit from its convenience.

Electrical work is based upon the centimeter, the gram and the second, the so-called C.G.S. system, which was adopted for it half a century ago by the Committee on Units of the British Association for the Advancement of Science. As it is within this last half century that pretty much the whole development of electrical business has taken place, the metric system is securely fixed throughout its present enormous extension in the work of technical character; nevertheless, in the purchase of supplies and the market transactions with the non-professional public, old usage with pounds, feet, etc., remains to be eliminated,

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with the minor exception that the kilowatt is commercially used. That is used for electric lighting in the kilowatt-hours of the bills rendered to consumers; and it has partially supplanted the anomalous old horse-power, particularly in connection with hydro-electric development. Legislative action has been taken to sanction the electrical units based on the metric system, Congress having enacted in 1894 that they should be the units of electrical measure in the United States, and having more recently made a law about wireless telegraphy.

Chemistry, technically pursued, has been metric for fifty years. No one looks for ancient units in a chemist's laboratory; but, in the business of chemical processes on a large scale and of the manufacture and sale of chemical products, there is great use of them, and as yet the substitution of the kilogram, liter, etc., has to be regarded as exceptional, — such as the cases of the Solvay Process Company, Syracuse, N. Y.; the Merrimac Chemical Company, North Woburn, Mass.; the Pennsylvania Salt Manufacturing Company; E. R. Squibb & Sons, Brooklyn, N. Y.; and the Bausch & Lomb Optical Company, Rochester, N. Y., who put out a price-list headed " Prices of Chemicals are by Metric, NOT Avoirdupois Weight." It would appear to be easy in such business to complete the substitution if the persons with whom the chemists had to deal would accept metric measurement.

Pharmacy affords a plain illustration. Chemistry and the metric system of course are thoroughly taught in colleges of pharmacy, and apothecaries have for many years put up metric prescriptions. Metric measure has been fully introduced in the " Dispensatory," the reference manual of the physician, and in the " Pharmacopœia," the reference manual of the apothecary. In the medical work of the U. S. Marine Hospital Service, the Army and the Navy, the use of the metric system was long ago required by successive executive orders without any special enactment by Congress. I am very glad that these specially trained persons have advantage from the system; but that does not affect most of us, who, when we have a prescription filled, do not concern ourselves about its composition and are conscious neither of profiting if it is in metric measure nor of suffering if it is in old scruples, minims or fluid ounces, of the magnitudes of which we are oblivious. Suppose, on the other hand, that in the apothecary-shop we purchase some gumdrops or other goods that are weighed out to us over the counter; neither the metric weight nor the ancient apothecaries' weight is used; this little transaction is commercial, and uses weight which we know as customary and which is called "avoirdupois." It is this avoirdupois weighing that it is important to have superseded by metric weighing, so that the great mass of our citizens, in the dealings with which they are concerned, may benefit by the change.

Similarly, the metric system is in use for making dietaries; but for the marketing of food supplies by provision dealers practical steps remain to be taken such as are now being urged in the National Wholesale Grocers' Association. According to an editorial article in the Boston *Transcript* of June 21, 1916, —

> "In pursuance of a report submitted by a special committee to the convention in Boston, every wholesale grocer is urged to print on the labels of all canned and boxed goods not only the weight in English pounds and ounces, but also the metric equivalent. This custom will have two values. It will help to educate the American people in the metric system, and it will begin at once to reap the benefits for American goods abroad, especially in the South American countries, which a general adoption of the metric system promises. Furthermore, the grocers are preparing for their membership complete and easily used tables of equivalents, and are doing their utmost to show how the first year or two of the change might be rendered less difficult by their use."

It appears that the committee has also proposed to have an organization to educate the public as to the advantages of the metric system.

Among the non-commercial applications of metric measure sports have drawn wide attention to it, especially the Olympic Games and international contests in great variety. The weight and strength of athletes and students in colleges also have been largely compared and measured by metric units. Works of art in museums have been catalogued with dimensions in the metric system. Such things help a little toward getting metric units into men's minds, which is the essential point of its adoption; but these matters are not commercial transactions such as everybody has to engage in. Quite apart from buying and selling, also, the metric system has been adopted in the work of some committees of the American Society of Civil Engineers. This appears in the report of the Committee on Uniform Tests of Cement, on pages 72–83, under Society Affairs, in the *Proceedings* for February, 1909, Vol. XXXV, No. 2; on page 79 is the paragraph, —

"51. — The metric system is recommended because of the convenient relation of the gramme and the cubic centimeter."

Also the Committee to Codify Present Practice on the Bearing Value of Soils for Foundations, etc., used millimeters for dimensions in its report, on page 346, under Papers and Discussions in the *Proceedings* for March, 1916, Vol. XLII, No. 3; and, with regard to its sub-committee "A," —

"It was agreed that, in all the work of this sub-committee, the metric system would be used, etc." (Page 419, under Society Affairs, in the *Proceedings* for August, 1915, Vol. XLI, No. 6.)

In manufactures and machinery, one of the first applications of the metric system in this country was nearly fifty years ago, at Waltham, Mass., to watches and tools for making watches (including metric screws), where it has been entirely successful. The same distinction as before may be made. When a man buys a watch he wants to know the time, not what machinery was used in manufacturing. That it has long been metric machinery does not directly benefit him even if he knows the fact; and if any or all manufacturers were still using old measure it would not directly injure him, who thinks nothing about it. Suppose, on the other hand, that the man is selling his watch-case as old gold for the melting pot, to be paid for by weight; in that commercial transaction it is to be desired that the weighing should be by the gram, the unit of the universal decimal system, rather than by any irregular old unit, and particularly by the incongruous, antiquated, if not forgotten, unit for which the abbreviation was "dwt." This could be done simply by the substitution in balances or scales of metric weights for old weights; nevertheless such commercial substitution has yet to be made generally, although in the technical work of mechanical and manufacturing establishments, as to which there has been a great outcry that change would be impracticable, the change has actually been made in many kinds of work, as in the case of watch manufacture. This is a humorous feature of the situation.

The Lafayette Worsted Company, of Woonsocket, R. I., made this statement about fourteen years ago, —

"A large proportion of our employees being from Europe, we use a good deal of the metric system for the inside wants of the mill, but we have to use the American measures and weights for the outside relations."

This was printed under the heading, "The Textile Industry and the Metric System," in the *Textile World* for November, 1902, among the replies to a questionnaire of prominent manufacturers representing the cotton and woolen industries throughout the United States. Another of the replies from the Massachusetts Mills in Georgia, Lindale, Ga., H. P. Meikleham, agent, contained the following sentence referring to the metric system:

"You are doubtless aware that a good many shops use this system."

So long ago as 1898, the last report which the Committee on Weights and Measures made to the Boston Society of Civil Engineers contained the following paragraphs (*Journal of the Association of Engineering Societies* for April, 1898, Vol. XX, Proceedings, p. 49):

"Your committee have ascertained that quite a number of manufacturering concerns in this country are using the metric system in their work in part or whole, particularly those concerns which do an export trade. A partial list showing some of the kinds of business using this system is as follows:

"Manufacture of watches and watch tools, injectors, machine tools, measuring instruments, steam engines, ordnance, refrigerating machinery, chemicals and iron works."

Important additions might now be made, including automobiles and their accessories and aeroplanes. An enormous increase in the manufacture of munitions for war has taken place, the metric system being used. As an instructive example, a short quotation may be made from the progress report of the American Society of Civil Engineers' Committee on the Status of the Metric System in the United States, printed among Society Affairs in the *Proceedings* for October, 1908, Vol. XXXIV, No. 8 (see p. 427):

". . . Your committee would cite the case of twenty locomotives built by the Baldwin Locomotive Works, in 1907, using the metric system exclusively, as described in the New York *Herald*, Sunday, June 16, 1907. Mr. Samuel Vauclain, vice-president of these works, in reply to an inquiry from your committee, states that there was no greater difficulty in working to the metric system than to the English system. In fact, it was found somewhat easier, and the workmen were less likely to make mistakes. Mr. Vauclain further states that they could change to the metric system or use both systems without incurring any appreciable expense at the time, and adds his opinion that, were we all using the metric system, it would be much more convenient to the workmen, and our errors would be appreciably lessened."

For us all to be using the metric system where we all have to act together, that is, in commercial transactions, it is not an indispensable condition (though it is a desideratum) that it should be in use in manufacturing processes at the same time, if some manufacturer for any reason, or for no reason, prefers at present to forego the advantages of having it inside his works for his own workmen. For us all to be using the metric system means that we must pay for our transportation by the kilometer and reckon freight by the kilogram or metric ton, in doing which we are not thinking of how the locomotive is built.

In England also it has been recognized that it is outside of the works that it is required to extend the use of the metric system. In a pamphlet which the Decimal Association issued some ten years ago, containing favorable opinions of Lord Kelvin and nearly a hundred other persons, there was on page 6 the following passage contributed by Lord Belhaven and Stenton, who has subsequently become president of the association:

"The opponents to this proposal appear to base their principal objections on the cost that it would involve to manufacturers to alter their plant and scales so as to work to centimeters instead of inches, etc. This, however, is not a necessary consequence. All that is proposed is that, in *trading*, goods should be sold by metric weights and measures. There is no difficulty in describing textile goods from existing looms and patterns in lengths of meters and breadths of so many centimeters. Similarly, machinery made on the present system can, if necessary, be described in metric terms."

On November 17, 1913, at a meeting of the Bradford Textile Society, the metric system was discussed, and the following remark was made by Mr. G. E. M. Johnson, the secretary of the Decimal Association:

"We do not propose to interfere with the interior arrangements of any factories or to inquire what standards are used there at all, so long as when the products are sold they are invoiced and described in the terms of the metric weights and measures."

To illustrate this simple matter of describing commercial quantities and dimensions in metric terms, a quotation may be made from what had been said just previously in the principal address of the meeting by Alexander Siemens, past-president of the Institution of Civil Engineers. Here it is:

"When before a parliamentary committee I was asked: 'Seeing that in the cotton trade the standard make is what is called 79 ins., $37\frac{1}{2}$ yds., $8\frac{1}{4}$ lbs. shirting, — which is known the world over, — wouldn't it in some way damage the reputation of the shirting if the figures had to be recalculated in all the markets of the world?' Well, at the time I had not sufficient time in which to make the calculation. What do you get when you recalculate? Seventy-nine ins. are 2 meters within one third of one per cent.; 37.5 yds. are equal to 34 meters to within one third of one per cent.; and $8\frac{1}{4}$ lbs. are $3\frac{3}{4}$ kilograms. So you see you have been entertaining angels unawares. You have been manufacturing to metrical measure."

Likewise, in the subsequent discussion, Mr. Siemens referred to the point again saying, —

". . . This change would not affect the processes of manufacturing in any shape or form. You would manufacture exactly as you have done before, only you would call the products by metrical names instead of by British names. As I showed you, 79 ins. by $37\frac{1}{2}$ yds. by $8\frac{1}{4}$ lbs. would be called 2 meters by 34 meters by $3\frac{3}{4}$ kilos, but the cloth would be manufactured in exactly the same way."

An actual instance of description in metric denominations for commercial purposes was spoken of by Mr. John Pilter, who appeared in the name of the British Chamber of Commerce in Paris before the House of Commons Committee on Weights and Measures in 1895; the Blue Book gives his answer No. 2098 thus:

"With regard to the sizes of pipes which a member of this Committee mentioned, we have those same pipes sold in France with the French measures, and we experience no difficulty whatsoever. Instead of it being a three-inch pipe it is a pipe of a certain dimension in French. That is all. We, ourselves, do a large trade in iron pipes. The interior and exterior diameters are given in millimeters. It is a very easy thing to understand."

The American Society of Civil Engineers committee report quoted above contains a paragraph which summarizes this matter (p. 425):

"Throughout the commercial world the great majority of manufactured articles would remain absolutely unaffected by a change in units of measurement, because commercial sizes are nearly always nominal, and a suitable metric dimension can always be found which will satisfy all requirements."

What it will suffice to get done about this at first is to get commercial sizes expressed in metric terms. The committee report illustrated the matter by an extended table giving the actual diameters of pipes with the old designations commercially used for them in one column and corresponding designations in round numbers of millimeters in another column; and the report went on to say, —

"The even nominal metric sizes are in nearly every case nearer the actual sizes than are the nominal inch sizes in the first column.

"In like manner, tables of round, square and other steel shapes can be expressed in whole millimeters with sufficient accuracy to come within the actual variations of trade sizes, so

# APPROXIMATE EQUIVALENTS.

## LENGTH.

| | | | |
|---|---|---|---|
| 1 in. | and | $2\frac{1}{2}$ centimeters | (2.54) |
| 1 ft. | ,, | 0.3 of meter . | (.3048) |
| **1 Yd.** | ,, | **0.9 ,, Meter** . | (.9144) |
| 1 rod | ,, | 5. meters . . | (5.029) |
| 1 ch'n | ,, | 20. ,, . . | (20.117) |
| 1 furl'g | ,, | 200. ,, . . | (201.17) |
| 1 mi. | ,, | 1 600. ,, . . | (1 609.3) |

## AREA.

| | | | |
|---|---|---|---|
| 1 sq. in. | and | $6\frac{1}{4}$ sq. centim's | (6.452) |
| 1 sq. ft. | ,, | 0.09 of sq. meter | (.0929) |
| 1 sq. yd. | ,, | 0.81 ,, ,, ,, | (.8361) |
| 1 sq. rod | ,, | 25. sq. meters . | (25.29) |
| 1 rood | ,, | 1 000. ,, ,, . | (1 011.7) |
| 1 acre | ,, | 0.4 of hektar . | (.4047) |
| 1 sq. mi. | ,, | 256. hektars . . | (259.) |

## BULK.

| | | | |
|---|---|---|---|
| 1 cu. in. | and | $15\frac{5}{8}$ cu. centim's | (16.387) |
| 1 cu. ft. | ,, | 0.027 of cu. meter | (.028317) |
| 1 cu. yd. | ,, | 0.729 ,, ,, ,, | (.7646) |
| 100 cu. ft. | ,, | 2.7 cu. meters | (2.8317) |
| (The unit of ship's measurement for register.) | | | |
| 1 M board meas. | and | $2\frac{1}{4}$ cu. meters . | (2.36) |
| 1 cord | ,, | 3.6 ,, ,, . | (3.624) |
| 1 U. S. liq. pint | ,, | 0.45 of liter . . | (.473) |
| **1 ,, ,, Qt.** | ,, | **0.9 ,, Liter** . | (.946) |
| 1 ,, ,, gal. | ,, | 3.6 liters . . | (3.785) |
| 1 peck | ,, | 9. ,, | (U. S. 8.81; Br. 9.09) |
| 1 bu. | ,, | 36. ,, | (U. S. 35.24; Br. 36.37) |
| 1 ton of ship's displacement | ,, | 1. cu. meter | |

## WEIGHT.

| | | | |
|---|---|---|---|
| 1 grain | and | $.06\frac{1}{4}$ of gram | (.0648) |
| 1 troy oz. | ,, | 30. grams | (31.103) |
| 1 avoir. ,, | ,, | 27. grams | (28.35) |
| 1 lb. | and | 0.45 of kilo | (.4536) |
| 60 lbs. (wheat bu.) | ,, | 27. kilos . | (27.216) |
| 80 lbs. (coal bu.) | ,, | 36. ,, . | (36.287) |
| 1 cental | ,, | 45. ,, . | (45.36) |
| 112 lbs. (cwt.) | ,, | 50. ,, . | (50.8) |
| **1 Net Ton** | ,, | **0.9 Met. Ton** | (.9072) |
| 1 gross ton | ,, | 1. ,, ,, | (1.016) |

## COMBINATIONS.

| | | | | | |
|---|---|---|---|---|---|
| | 1 horse-power | and | $\frac{3}{4}$ of kilowatt . . . . . . . . . | (.746) | POWER. |
| | 1 foot-ton (net) | ,, | 0.27 of (metric) ton-meter . . . . | (.2765) | WEIGHT AND LENGTH. |
| | 1 foot-pound | ,, | $0.13\frac{1}{2}$ of kilogrammeter . . . . . . | (.1383) | WEIGHT AND LENGTH. |
| | 1 pound per running yard | ,, | $\frac{1}{2}$ kilo per running meter . . . | (.4961) | WEIGHT PER LENGTH. |
| | 1 ,, ,, ,, foot | ,, | $1\frac{1}{2}$ kilos ,, ,, ,, . . . | (1.4882) | WEIGHT PER LENGTH. |
| | 1 pound per sq. foot | ,, | 5. kilos per sq. meter . . . . . | (4.882) | WEIGHT PER AREA. |
| (About 1 atmosphere) | 1 net ton ,, ,, ,, | ,, | 1. kilo per sq. centimeter . . . | (0.9765) | WEIGHT PER AREA. |
| (About 1 atmosphere) | 15 pounds ,, ,, inch | ,, | 1. ,, ,, ,, ,, . . . | (1.0546) | WEIGHT PER AREA. |
| | 1 ,, ,, ,, ,, | ,, | 0.07 ,, ,, ,, ,, . . . | (.0703) | WEIGHT PER AREA. |
| | 1 net ton ,, ,, ,, | ,, | 0.14 metric ton per sq. centimeter | (.1406) | WEIGHT PER AREA. |
| | 1 pound per cu. foot | ,, | 16. kilos per cu. meter . . . . . | (16.02) | WEIGHT PER BULK. |

that with an allowable variation of 3 per cent. in sections, a change to the metric system would be a change in name only" (p. 425).

Going a step further, with only one decimal of the millimeter, metric value for all the customary subdivision of inches can readily be substituted. The inch is truly 25.4 millimeters; call is 25.6 millimeters and $\frac{1}{16}$ inch becomes 1.6 millimeters, and 0.1 millimeter is thus the substitute for $\frac{1}{256}$ of an inch; and every expression by the usual bisection of inches down to 256ths is simply provided for. This is easy compared with finding the equivalents in decimals of a foot, as we have been doing; and is not so far from correct as calling 2 ins. 0.17 of a foot and 4 ins. 0.33 of a foot. Its error is less than one per cent., being only half as great as in the familiar substitution of 25 millimeters for an inch; and it is close enough for the many occasions in which exact equivalence is not needed.

Another illustration of trade requiring metric denominations, regardless of what measure is used in manufacturing goods, was mentioned incidentally in the case of engines built by Williams & Robinson, at Thames Ditton in England. They had indeed introduced the metric system with complete satisfaction to their workmen and other parties concerned, as testified by Capt. H. R. Sankey, one of the directors of the company, in 1895, before the House of Commons Committee on Weights and Measures; but among his answers to questions he made a statement about their continuing also to make engines in the old style and dealing in them abroad where commercial measure was metric, saying (per page 73 of Blue Book, question 1241):

". . . We sold some engines in Holland, and our Dutch agent — and I believe Holland is one of the places where English machinery is most welcome — wrote bitter letters to us saying that he could not get any orders until all the dimensions were translated into millimeters. I do not mean the working dimensions, but what may be called 'customers' dimensions, the length and height, and certain other dimensions of that kind. He had to translate those, and in view of that we issued a new circular in which our older line of engine dimensions were mentioned both in millimeters and English dimensions."

Another witness to the point that engines built by old measurement might be put on the market in metric terms was Col. R. E. Crompton who, in a discussion June 1, 1908, published by the Society of Engineers, London, said that he had the two systems alongside one another in his works; he was reported in part as follows:

"If he turned out a steam engine of a certain size from his workshop, what would it matter that it had been designed in inches, although the purchaser might have it listed to him in millimeters? It would make no difference," etc.

*Some Matters in which Coöperation with the United States Government is Wanted.* — Mention has been made of some branches of business in which there has been adoption of the metric system by the United States Government, the largest user of weights and measures. An obvious step remaining to be taken is to have the use of the metric system extended through any commercial transactions of the United States Government where it has not already gone. If the Government advertises for bids for an engine let metric measure be used for the dimensions by which it is designated. If bids are received for pipes let metric units be used to designate their diameters. Metric units have already been used to designate the caliber of rapid-fire guns in naval armament. Let the prices bid for food supplies, or for fuel, or for dredging material in rivers and harbors, be prices per metric ton or per cubic meter, etc. Our citizens have such desire to obtain government contracts that they will not fail to bid and to coöperate in the application of metric weights and measures. That these may be brought into use among the people generally is the chief benefit to be obtained from their exclusive use by the United States Government.

A very important step which needs to be taken in coöperation with the United States Government is to secure action by the separate states. They have to do a great deal of commercial business involving weighing and measuring; and old units ought to be abandoned therein at the same time as in the United States Government business. The teaching of the metric system to children in schools is for the state governments to attend to. The verification and sealing of commercial weights and measures, and the detection and punishment of fraudulent weighing and measuring, are now in charge of the state and municipal authorities. Many details require careful attention in conducting a change; one illustration is that it has been usual to make metric weights in hexagonal form instead of in the round form common for old weights, this difference being a precaution against mistaking one set for the other. There is danger that, under the guise of changing to the metric system, rogues may try to set up some false weights or measures. The United States Government does not now have an organization suitable for looking after all the practical details throughout the country, and it would seem unreasonable for it to create one independent of the states.

*Some Matters completely within the Control of the United States Government.* — The United States has a postmaster in every village, and, by supplying them all with metric scales, could extend the change to the domestic service in the Post-Office Department. The citizens would not be likely to object, since 30 grams, the metric weight for a single rate, is nearly 6 per cent. more than one ounce. On the statute book for about half a century there has been the following provision (Section 3880):

> "The postmaster-general shall furnish to the post-offices exchanging mails with foreign countries, and to such other offices as he may deem expedient, postal balances denominated in grams of the metric system, fifteen grams of which shall be the equivalent, for postal purposes, of one-half ounce avoirdupois, and so on in progression."

This throws a sidelight on the problem of legislation. It was doubtless intended by this enactment to lead us to use the metric weight in the domestic service of the Post-Office Department; but the officials have treated it as simply allowing the old weight to be continued in use. It remains for a mandatory regulation to be adopted and for the weights and limiting dimensions of packages, etc., to be expressed metrically in all the published announcements and notices of the service; this has been too often neglected. The metric basis is securely fixed, having been adopted in the Postal Union treaty originally made in 1874.

Even opponents of its general use have admitted that it is the standard to which to refer various national reckonings in service like that of a clearing-house.

In coinage, the metric system has been introduced in the United States and in other countries. Our subsidiary silver coinage for forty years has weighed one gram per four cents; and our citizens could weigh their letters to determine postage required by balancing them against $1.20 in subsidiary silver. A step that remains to be taken, however, is to get this fact thoroughly into the minds of the people; when a man gives or takes a half-dollar coin, he is not apt to think of its weighing 12½ grams or to have any thought of how heavy a gram is. I deem it highly desirable that upon the obverse of the subsidiary silver coins their weights in grams should be stamped. They go into everybody's hands; their design is absolutely in the control of the Government; the idea of associating coins with weight is of course ancient and fundamental. A weight somewhat heavier than a gram has been called a pennyweight; let us think of the weight of a gram in cents. The weight, 420 grains, was stamped upon the United States trade dollar, millions of which were struck about forty years ago for commercial purposes in the Orient. It may require an act of Congress to accomplish this.

Another thing which the Government can do is to use metric units exclusively in the Weather Bureau's announcements and charts, as it has heretofore done on the international charts. To use only kilometers for wind velocities and only millimeters for precipitation would bring these units into the minds of those who study the weather.

I will take up one more branch of business and that is the customs service, which might well be attended to in advance of most of the other applications of metric weights and measures, as has been the case in the introduction of the metric system in many countries. The collection of customs duties has to do with trade connected with foreign countries, and is in some degree detached from general domestic business. An executive order by the Secretary of the Treasury might establish the metric system, whether people liked it or not, in exclusive use in the custom houses on short notice, merely enough to warn merchants to have their invoices prepared to meet the requirement. The existing law legalizing the metric system fixes the ratios by which conversions may be made from old customary units; and surely it would be a simple, though possibly monotonous, undertaking to calculate, if necessary, the metric equivalent of quantities of goods or rates of taxation expressed originally in terms of other measure. It is within the power of the United States Government to say what measure, established by it for many years, it will allow to be used in passing goods through its custom houses, as it is within its power to say what money it will accept in the payment of customs duties, refusing, for example, to accept British sovereigns or Mexican pesos or even its own " greenbacks," upon which it prints. " This note is a legal tender at its face value for all debts public and private except duties on imports and interest on the public debt."

*Our Immediate Opportunity.* — Ignoring or neglecting the matter would mean continuance of our annoyance and expense in hanging on generally to antiquated commercial units out of harmony with the metric system which is recognized as the established basis of all measurement. Not all of our fellow-men are so apathetic and inert as to let them be protracted indefinitely. The Second Pan-American Scientific Congress at Washington, in January, 1916, urged the thoroughgoing use of metric weights and measures as stated, on information furnished by the late Dr. Corthell, in the February JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS, Vol. 3, No. 2, p. 69. Dr. Corthell wrote, January 12, 1916, that the matter would be followed up, saying:

" . . . The opposition, which has been very strong and sometimes bitter, has gradually yielded, and one or two of the strongest opponents have seen a new light; and one of them is already an advocate of the metric system."

In the April *Munsey's Magazine*, a monthly which has a large circulation, there was an article entitled, " The Metric System," the tenor of which is indicated by its first sentence, reading thus:

"Pounds and ounces, gallons and quarts, tons and hundredweight, miles and yards, feet and inches, acres and square feet, are making ready for their exit from the stage of American business affairs."

The article told about a bill for the promotion of that object being considered in Congress.

The *Ladies' Home Journal*, which claims a circulation of 1 750 000 copies, has in its number for May, 1916, a short article, entitled, "What Inches Cost," two sentences of which are as follows:

"It is estimated that if Congress would make the metric system the standard for this country it would save American business one hundred million dollars a year. . . .

"Scientists and many industrial establishments are already using the metric system; it is only a question of time before the householder will also enjoy its benefits."

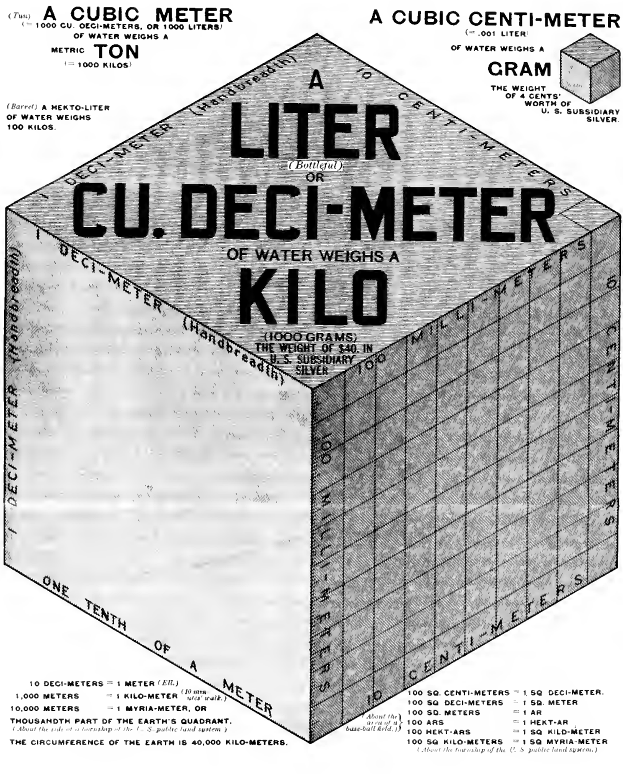
The editor indicates that an account of the metric system can be obtained by any subscriber on application.

The metric reform has been vigorously advocated for years by the *Valve World*, the monthly publication of the great Crane Company, manufacturers of steam and plumbing supplies.

Are the members of the Boston Society of Civil Engineers modestly to efface themselves and to leave it entirely to the patriotism of the wholesale grocers, the magazine editors and others, to determine how the weighing and measuring of the United States is to be done? In his address at the annual meeting in March, the retiring president of the Society, Mr. Charles R. Gow, with commendable public spirit, referred to the desirability of engineers and engineering societies participating individually or collectively in attempts to influence or direct public affairs, mentioning that our Society had taken some steps in this direction by the creation of a legislative committee whose function it was to observe attempted legislation on questions affecting engineering (April, 1916, JOURNAL, Vol. 3, No. 4, p. 129). It seems highly desirable that a matter so important as this of the metric system should receive the attention of a special committee of the Society at the present time as it did during many years, 1875–98. As to whether it was proper that the Society as a body should take positive action on the metric question, there was much discussion; and it has been recognized as clearly permissible for any statement or petition to receive the signatures as members of the Society of as many as please to sign it. Others might sign, as members of the Society, some different or contrary statement or petition if they preferred.

What should be prayed for? I have pointed out a few particulars of what I should like to have brought about by governmental action; but possibly the Society or a committee might think that a detailed program should not be prescribed in a petition, but should be left to Congress or the executive departments. Our purpose is to let the authorities know that we wish for the general result; the more citizens of intelligence and influence are known to favor it the greater the probability of vigorous action being taken. I recommend that members of the Society petition for an enactment that, from July 1, 1920, the metric system shall be exclusively used in all commercial transactions to which the United States is a party. I take the date from a bill introduced in Congress; any other date might be substituted. The date should be so fixed as to allow for the branch of business requiring the longest time; then let changes in other branches of government business be made as much earlier as seems fit to the officials in charge. This program resembles what was done by the American Institute of Electrical Engineers. Its resolutions favored the introduction of the metric system into general use in the United States at as early a date as possible without undue hardship to the industrial interests involved, and such legislation by Congress as shall secure the adoption of the metric system by each department of the National Government as speedily as may be consistent with the public welfare. The resolutions having been prepared by the Standardization Committee were by order of the Board of Directors submitted to the membership for letter-ballot; 1 569 votes were cast in favor and 178 against the resolutions; and it was ordered that notice should be given accordingly to the Congressional Committee in charge of the metric bill. This was in 1906, and reference may be made to the report of the Board of Directors printed in

PLATE II.
JOURNAL BOSTON SOCIETY OF CIVIL ENGINEERS.
SEPTEMBER, 1916.
BROOKS ON
METRIC SYSTEM



the June, 1906, Proceedings of the Institute, Vol. XXV, No. 6, p. 14, and to the *American Machinist* of May 26, 1906.

Mr. Weston.* — That our present system of weights and measures is cumbersome and tied to the chaotic past, is conceded by nearly every educated man, but the adoption of the simpler and easier-used metric system is a matter of some difficulty, just as was the adoption of the dollar by our fathers, in place of the shilling. This required time. Even to-day a quarter of a dollar is "two bits" in some sections, and my respected grandfather always referred to a half dollar as four shillings.

The speaker is not going to debate the question of decimal *v.* duodecimal systems, and will admit the convenience of the latter to the architect, artisan and average man, when it becomes necessary to divide into halves, quarters, eighths, etc. The use of a scale divided into tenths and hundredths, which all of us use, may be acquired after a little practice, and the purchase of crackers and candy by the kilo is not a difficult matter if one has the price.

Those of us who have been brought up in the field have long ago discarded the link, the furlong, the rod, Gunter's chain and the like, and have used the mile, the foot and other decimals. To such, the use of the metric system would hardly pay for the change if the mile and the foot could be used apart from other measures; but such is not the case, and those of us who have worked in engineering laboratories know perhaps better than anyone else how much time could be saved by the metric system, which, as you know, presents the frequently lost-sight-of advantage of the same unit for lineal, surface and capacity measures and volumes.

With the metric system in use, we all would really know our weights and measures, as even the educated among us do not at present. How many among you know the weight of a scruple, a karat, a dram or a pennyweight, or that the troy ounce is heavier than the avoirdupois ounce? In fact, most of us know what we use and little besides except as our memories may retain something we acquired in our grammar-school days. Chemists and electrical engineers have long used the metric system, and

* Of Weston & Sampson, Consulting Engineers, Boston.

even among civil engineers the term "kilowatt-hour" has now no terrors for anyone.

To my mind, the interchangeability of weights of water, measures and volumes is the greatest advantage of the metric system, and well worth whatever pains are necessary to bring it into daily use among us. Take a class of computations we make frequently in our office, an example of which is the following: To a tank of water 40 ft. long by 30 ft. wide by 11 ft. deep, how many pounds of, say, lime must be added to be equivalent to 60 parts per million?

By the United States system, we multiply the dimensions and obtain 13 200 cu. ft.; then this must be multiplied by 7.48 to obtain 98 600 gals.; then we multiply 60 parts per million by 8.34 to obtain the equivalent number of pounds per million gallons, namely 500.4. Then the quantity to add to 98 600 gals. is 9.86 per cent. of 500.4 lbs., or 49.7 lbs. per million gallons. We have no avoirdupois scale with the pounds graduated in tenths, so we multiply 16 ounces by $\frac{7}{100}$ to get the ounces and fractions, and arrive at 11.2 ozs. The total amount to be added, to the nearest quarter ounce, is therefore 49 lbs. 11¼ ozs.

Take the same problem when the basin is 12 meters long, 9 meters wide and 3.3 meters deep — these measures being approximately equivalent to the ones just given. The product of these three dimensions is 356 cubic meters. This is 356 metric tons of water, or 356 000 kilograms, or 356 000 liters. Sixty parts per million is 60 milligrams per liter, or 60 grams per ton, or 60 grams per 1 000 kilograms. Therefore we can obtain our results in grams by simply multiplying 356 by 60, which equals 21 360 grams, which, divided by 1 000, is 21.36 kilograms.

In all water filtration operations, the metric system greatly facilitates computations, and the same would be true of all hydraulic computations involving the factors 62.4, 7.48, 8.34, etc. The speaker has decided that in the next water purification or sewage disposal investigation he will use the metric system entirely and convert the results into United States equivalents at the end, and thus make a great saving in computations during the investigation.

Savings in time may be made in other computations than the ones mentioned. Take, for example, the conversion of pounds per square inch of water pressure into feet of head. Now we have to multiply by 2.307, but one kilogram per square centimeter is the head produced by 1 000 cubic centimeters of water, which is equivalent to a column of water one meter long with a cross-section of one square centimeter. Therefore one kilogram per square centimeter is equivalent to one meter of head.

Other computations are equally simple. The kilowatt-hour is 1 000 watts, and the metric horse-power, which is within two per cent. of our present standard horse-power, is equivalent to 75 kilogram meters per second.

Before the metric system can be adopted, there must be difficulties. Men and machines exist, and our present system is tied to them and their past. Ample time should be allowed for the change and for the education of the users. If the more logical and simpler metric system can be brought into use, I believe that many of the units are so near the older units in value that some of the older names will be retained for a long time. Thus we may expect to have 500 grams called a pound, 250 grams a half pound, a liter a quart, and the 2 206-lb. metric ton replace the 2 240-lb. long ton. Again, 300 centimeters is nearly a foot; the metric and United States horse-powers are practically the same, and one B.t.u. is about a quarter of a calorie.

Those of us who use measures or weights of one system almost exclusively do not appreciate the difficulties of our present system, as well as those of us who have to use laboratory results and electrical data based on the metric system in conjunction with the present system of weights and measures; and if we lived in England our plight would be worse. They say that the English are the best mental arithmeticians in the world. They have to be, for with their 14-lb. stones and 112-lb. hundredweights and all, they must have to make prodigious efforts to keep pace industrially with competing European nations. Those of us who have seen an English set of books or an English engineer's computation sheets, realize how much more time they lose than we, and we lose much more than the French, Germans and South Americans.

The speaker firmly believes that the United States must use the metric system if we are to become an efficient world power and enter with the least friction into the markets of the world. When one takes a little time to master the system, its extreme simplicity and universality become plain. How little time is really required was exemplified at one of the largest chemical manufactories in New England, whose vice-president told the speaker that it took but a few hours to teach ordinary laborers to read meter rules and meter and kilogram gages.

Like many another good thing, the American birth of this system must be attended with considerable pain, but I, for one, am sure that the result would be well worth the labor required to bring it into our professional and private lives. Individual effort cannot introduce the system, however. The Government must take action in its own departments, and let the rest of the country gradually fall into line.

MR. PARKER.* — I have been deeply interested in the metric system for many years. My business is structural steel work and we use feet and inches, and we are not afraid of thirty-seconds and sixty-fourths of an inch. We must work accurately. Engineers are sometimes satisfied with the hundredth of a foot, not so the bridge builders.

There is no question of the beauty and utility of the metric system, and we ought to use it. About thirty-five or forty years ago, I was fascinated with the whole system and gave some illustrated talks on the subject to lyceums and young people's associations. I made wooden models of the meter and cubic decimeter, the latter marked off into little cubic centimeters and divided into sections to be taken apart to show the deciliter, centiliter, and milliliter. I made a tin liter that was just filled by the cubic decimeter, and a tin milliliter to hold a cubic centimeter of water or one gram in weight. With these models, a half hour sufficed to give an intelligent idea of the system to young and old in an audience. They would grasp it quickly, and some have since told me they never forgot it. It is not made interesting in our schools. High-school pupils have told me that they hate it. I think it is because the book tables are filled

* Supervisor of Steel Work, Boston Transit Commission.

with long fractional values in the English system. The metric system is very simple. I tell all that I talk with that the metric units are one tenth larger than the English; the meter, a yard and a tenth; the liter, a quart and a tenth; and the half kilo, a pound and a tenth. That is the simplest way I know. We must learn to think in the metric dimensions and sizes. In teaching, don't dwell on the English values, but just hold up the meter and liter models and show that there are only four unfamiliar names absolutely essential to learn, viz., the meter, the liter, the gram, and the prefix "kilo." When they see that these names mean, in order, measure, quantity and weight, and "kilo" 1 000, they realize how simple it is. The deci, centi and milli prefixes we have in familiar use in our dimes, cents and mills. We hear little about dekameters and hektometers and myria-meters, but much about meters and kilometers. We seldom speak of the yard, but often of feet and miles. I think it was in 1796 or 1797, when John Adams was President, that the metric system was legalized in the United States.

MR. BROOKS. — The metric system was legalized in 1866.

MR. PARKER. — I thought I had read that John Adams recommended it.

MR. BROOKS. — Jefferson, when Secretary of State under Washington, made a report, but I think it was not the metric system. John Quincy Adams, Secretary of State 1817 to 1821, published a very elaborate report. It was a very learned and elaborate report and discussed the metric system to very great length. But the system was not legalized until 1866.

MR. PARKER. — I have talked with some of my workmen about the metric system, and they speak against it. It is because they don't know about it. When you learn it and see the saving of time it effects, you long for it. The other noon I spent a few minutes in telling a carpenter, a template maker, and some other mechanics about it, and they got much interested. They will not forget it. They didn't know what it meant before, and hadn't realized that it was the familiar dime, cent and mill applied to measures. It seems to me the first important thing is to have people know what it is, and anything to promote that will be very helpful. I shall try to convert more of those workmen who are against it. I saw an absurd article in the *Herald* the other day, against the metric system. The writer evidently didn't know the details of the system correctly. I think it would be a good idea for Congress to set a date on which the system will be compulsory, and then we will adjust ourselves to it. If there was a date set, the different firms would anticipate the day and have everything ready, and the system would come into use naturally and rapidly. The difficulties now seem formidable to many. So far as scales are concerned, there are now many balanced scales in use. We have them in chemical laboratories and in many stores, and either metric or the English weights can be used. All the graduated scales would of course need new beams or new drums. Scales with revolving beams giving the metric or English weights are now used by the post-office in weighing parcel-post matter. The greatest difficulty that I see in the mechanical world is the changing of our taps, dies, threads and gages, but we would rejoice when the numerous gages and threads now in use were replaced by one uniform standard. A customer going to a store would soon learn to ask for a liter instead of a quart. With the English system we had three quarts in use, — wine, beer and dry. A while ago the wine quart drove the beer quart out of use, being the smaller. To show the saving of time, take for instance articles billed with prices per square foot. Dimensions of, say, $7\frac{1}{8}$ ins. wide and 3 ft. $6\frac{5}{8}$ ins. long, and various other sizes. First you must reduce all these inches and fractions to decimals of a foot, and it takes quite a while to figure a bill with fifteen or twenty items on this basis. If it were in metric dimensions, how simple it would be, being in decimals from the start! You know at once in the metric system what a thing weighs if you know its dimensions or bulk. It is beautiful.

I suppose it is too late to consider any other decimal system, as I believe there are about thirty nations now using the metric system. In the Waltham Watch Factory the metric system is used exclusively, and the paper manufacturers are fast coming to sell their goods by the hundred. Reams and quires are being done away with. The metric system is coming, but the Government could hasten it. German manufacturers will make drawings for steel work with the English dimensions for the sake of getting trade here and in England, furnishing the steel work ready to erect. I think we ought to get everybody familiar with the metric system. Most people, when they know about it, are delighted. To have people want it they must first know what it is, and learn how simple it is, and how much time it saves. Mr. Brooks thinks we should work as individuals instead of as a society. But I think that all engineering societies and other bodies, such as boards of trade and chambers of commerce, who see the benefit which would come from the change, should urge Congress to act. Petitions also should be prepared and signatures obtained by the thousands and presented to Congress. The individual work will prepare the public to bring pressure on the Congress. I have always thought it was a pity that the world didn't have the duodecimal system instead of the decimal. Instead of stopping at nine characters or figures have two more, say, an inverted 7 (Ⅼ) for the tenth character, and an inverted 5 (ꞩ) for the eleventh character, then the zero for the twelfth. This would enable us to make divisions without remainder or fractions by one, two, three, four, six, and with simple fractions by eight and nine, whereas the decimal system admits only of divisions by two and five.

Mr. Adams.* — When I opened an office in 1879 I thought so well of the metric system that I wanted to do what I could to advance it, and I did actually take measurements with the meter as the standard, and in order to give my clients what they wanted I added the feet and hundredths; but all the work was done metrically. I put the dimensions on plans in meters, and decimals, and then in parentheses put in feet and hundredths. Of course all the measures, that is the steel tapes, were in decimal divisions, even the feet; but I found no difficulty with my assistants in the use of the meter, although they were taught entirely with the use of feet and hundredths, or feet and inches and sixty-fourths. They really seemed to feel a kind of relief to get on something that didn't get all mixed up. Of course, that didn't apply to feet and hundredths, but it did apply to feet, inches and sixty-fourths. I kept that up until I went to work for the Gov-

* Landscape Architect and Civil Engineer, Boston.

ernment, although I didn't entirely use the meter the latter part of the time. It was in 1885 that I went to work for the Government, in the lighthouse service.

The most practical difficulty that I had was in getting a really good metric measure; that is, the metric steel tapes were not as good as the other steel tapes in feet and hundredths. You couldn't get them as good then. It wasn't so much that my metric tape wasn't accurate, but the steel wasn't as good to work with. It was too soft; the figures wore off. It wasn't the fault of the system; it was simply the fault of those who were trying to sell the measures. I had office furniture made and had the drawings made metrically, and simply took a meter stick, that cost me seventeen cents, I think, and handed it to a carpenter who hadn't seen one before and told him to make a table. It had round edges and was rather complicated with a large number of drawers. The carpenter had no difficulty whatever. I asked him afterwards whether it bothered him any, and he said no, all he had to do was to take the meter stick divided and use the figures on the drawing. I found the practical difficulty in actual use in being obliged to change into the common or accustomed system, and that introduced extra expense in work that had to be given in feet and hundredths or feet and inches. On that account I gradually dropped the use of the meter and took the feet and hundredths, because that would be more readily changed either way. I was with the Government about nine years. All work I have done since then has been with the feet and hundredths. But, on some work I have been doing the last week, if I could have had the metric system and the client had understood it, a great deal of misunderstanding, slowness in figuring, and so on, would have been saved. The work related to the introduction of a water supply, where we had the cast-iron pipe in feet and tons and under 100 lbs. pressure or under 231 ft. head. If we had been talking on the metric system, we should have saved ourselves considerable time and understood each other a good deal more readily.

Mr. Brooks.* — I heartily concur in the opinion expressed by Mr. Weston, about simple relationship between different

* Author's closure.

units, and think that that constitutes the greatest advantage of the metric system. That it is not more generally appreciated by those who have tried the system only in awkward connection with other measure is like a painting not being appreciated by a blind man or music not being appreciated by the deaf. They are so accustomed to our old units, surviving from various ancient systems and brought into inharmonious contact with one another, that they don't ordinarily realize what it means to have units related in one system. The systematic character of the metric weights and measures makes them easier to learn and remember, causing great saving of effort and expense in school-teaching; gives better mental grasp of magnitudes and quantities numerically expressed; makes it simpler to calculate about them; and enables us to dispense with numerous tables that have been used in dealing with incongruous old measures and have been liable to contain errors and to have been out of reach when wanted. This advantage, which might well have caused the use of the metric system everywhere, has had little influence upon commercial traffic; what has caused such commercial use as has been brought about is chiefly the requirement of our relations with foreign countries, regardless of whether it was liked or not. That international intercourse furnishes great occasion for introducing the metric system is illustrated by several items before mentioned; also by the agitation of the subject in Great Britain, about which I will now speak.

It is quite possible that Great Britain will bring about the completion of the metric reform sooner than the United States will. Over there, at the meeting in February, 1916, of the Association of Chambers of Commerce, the following resolution was passed:

"That this Association strongly recommends all manufacturers, merchants and traders to adopt the use of the metric system in price lists and invoices in all transactions with countries using that system, and that the Executive Council be requested to invite all chambers of commerce to make a report as to the best means to be adopted for the purpose of introducing a decimal system of coinage into the United Kingdom."

In the Decimal Association's annual report, of which mention has been made, special prominence was given to the proposition that to capture South American trade Great Britain must use the metric system. The report included a similar suggestion of assistance to be afforded to British firms in competition with foreign countries in referring to resolutions favoring the adoption of the metric system from the Council of the British Horological Institute in May, 1915, and the Report of the Committee of the London Wholesale Jewellers and Allied Trades' Association in February, 1916. The following sentences also may be quoted from the Decimal Association report:

"One of the results of the war is the remarkable extent to which the metric system is being assimilated in the life of the nation. The presence of our military men in France and Flanders, and of Belgian and French refugees in our midst, has helped to this end. The nation has already had to experience so many violent changes that it is more ready than formerly to entertain proposals of reform. . . .

"A proof that more individual firms are using the metric system in their business is the fact that, in 1915, 38 373 metric weights and measures were submitted for testing in the city of London. Only a few years since the number was under one hundred per annum, and in 1914 was 1 741."

The report also tells of a canvass made by the *Electrical Review* among electrical engineering firms, in which, excluding the doubtful, there was a majority of four to one in favor of the general adoption of decimal coinage and the metric system in Great Britain; and of a similar canvass with like result made by Richard Klinger & Co. among engineering and kindred trades.

The conspicuous thing in recent British propaganda is the inclusion of money in the proposed decimalization as just now mentioned. For twenty years the Decimal Association was postponing the subject of money, while pressing the metric reform involving weights and measures; but it now urges the decimalization of money, taking as the unit one tenth of the pound sterling. One condition favoring the accomplishment of this project is that it permits the continuance in use of nearly all the existing gold and silver coins with some changes of name. The unit, having twice the value of the shilling, is represented by the current florin silver piece introduced in 1849 with the inscription upon it "one florin, one tenth of a pound." Though that inscription had been omitted in more recent coinage, the original intention evidently was to promote decimal reckoning. The sovereign is thus a piece of ten florins: the half-sovereign, of five florins; the shilling is $\frac{50}{100}$ of the florin, or 50 cents; and the sixpence becomes 25 cents, or a quarter of a florin. Among the proposed new nickel and bronze coins, one is of unusual denomination, namely, a 4-cent piece, or twenty-fifth part of the florin, the purpose of which is to take the place of the present penny, or twenty-fourth part of the florin, because that has been so prominently in use for petty payments.

The inclusion of money offers the advantage of correspondence in arithmetical progression of weights and measures with money, a similar advantage to that which I was just now expatiating upon as not justly appreciated by our people generally. We may well take heed of this as a stimulus to quicken our riddance of old units in commercial transactions in the United States. Allow me to quote a single sentence from the report of the Boston Society of Civil Engineers' Metric Committee, dated October 15, 1884, as printed in the *Journal of the Association of Engineering Societies*, Vol. V, p. 30, as follows:

> "In Sweden, in 1848, Mr. Wallenberg opposed the decimalization of money without weights and measures, because a visit of three years to America had shown him how inconvenient in business is a duodecimal system of weights and measures combined with a decimal currency."

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# DISCUSSION OF "REFORM AND REGULATION."

By Messrs. D. C. Jackson, F. P. Stearns, A. R. Weed, J. P. Snow, S. E. Thompson and A. C. Humphreys.

Mr. Jackson.* — Our present-day commission control of public service corporations — which is the main subject that the distinguished and able speaker of the evening has taken for illustrating his theme — is young. It is found in more than 40 states, some of which are old and fairly conservative, and others younger and less conservative. In certain few of the states, commission control of the public service companies has been in vogue for several decades, but in most of the states it has been a matter of but few years. Under such circumstances it is not unexpected that sharp differences of opinion arise under commission procedure, and also that differences of practice arise as between the commissions themselves, for a fixed basis for judicial consideration of commission cases has not yet been established. In fact, such a fixed basis cannot be established until men who are in touch with the affairs which come within the perview of these commissions have reached agreement upon fundamental principles. I may be permitted to express regret that the distinguished speaker of the evening did not lay before us an analysis of such principles which his wide experience would lead him to formulate. Lacking an accepted set of definitions of the duties of the public service corporations to their patrons, other than the contradictory statutes of our various states and a few pro-

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visions of common law not yet swept away by the deluge of statutes from our legislative halls, thoughtful men fail to find common ground for their minds to meet, and heedless empirics are under no restraining influence in their utterances.

Part of the difficulties set forth by Dr. Humphreys rest on the lack of understanding on the part of the average man of (1) the difference between a small business, like running a corner store, with the proprietor in personal relations with his customers, and a big business which employs thousands or tens of thousands of men whose sales employees only get in touch with the customers, and (2) the difference between a business which turns over its capital from one to five times a year like a mercantile business, and a business that turns over its capital only once in from three to ten years — like a public service business. These differences the average man will never understand until he has had some of the corporation securities and comes to appreciate the situation by studying it from the inside as a part owner.

At the present time there is an unfortunately small percentage of the nation's population directly owning a part in the public service corporations of local and national import. The number of stockholders of the steam railroads in the United States, according to the Interstate Commerce Commission, is under 625 000. This is an impressively large number of people when considered by itself, but if each one of 625 000 stockholders represented a separate family, it would include only about three per cent. of the families of the United States. There are probably three times as many families represented in operating the railroads. A wider distribution of corporation securities among the people of the nation would be serviceable both to the people and to the corporations, by bringing closer relations and more intimate understanding. Indirect relations, through the savings banks and the insurance companies of which Dr. Humphreys speaks, do not serve the same end as direct ownership. Some of the more general spreading of the securities which is desirable might be accomplished if the corporations would issue their stocks — and more particularly their bonds — in smaller denominations, as the French government does its government notes called *Rentes*.

Some may wonder why corporations are formed. They are formed because in these days of industrial affairs industries must be so big for the purpose of economy of production that no small group of men can or will undertake to handle them, and consequently it is necessary to have some coöperative arrangement whereby hundreds, thousands or ten of thousands of individuals may conjointly provide funds to make up the necessary capital. A corporation is simply a large enterprise intended to be run on a representative basis. If the management sometimes becomes rather more like machine politics than true representation, that is a thing that may be and should be reformed; but it is no reason to charge that all corporations are wrong because some have done wrong.

The whole theory of modern economics is built up under the influences which were introduced by the development of steam power, bringing into the service of humanity the very potent agencies of the steam railroad, ocean navigation, the telegraph, the telephone and the general use of mechanical power. These are engineering industries, and when it is remembered that the great Rainhill experiment, in which George Stephenson proved that a steam engine could beat horse traction, occurred as recently as 1828, it will be recognized that the railroad is young. The telegraph is younger, the telephone is still younger, electric light is in its babyhood and electric power transmission has hardly been germinated. Under the circumstances it is hardly to be expected that the final economic theories should yet be worked out for the new conditions under which we now live.

The engineers are responsible for these economic changes that have produced the large corporations, and it is doubtless right that we should undertake some of the responsibility for seeing that they are made most serviceable. The progress of corporations or their equivalent cannot be prevented. The great corporation is one of the manifestations which accompany the improved means of convenient transportation and speedy telegraphic intercommunication which are characteristic of the age in which we live.

Men of this age of course do not desire to relinquish the benefits of these improvements, and we have got to adjust our processes so that we may realize the advantages to the full, and ultimately do away with any disadvantages which cling to the economic structure. There are various means of accomplishing this, but it is not necessary to go into them here. Statesmen and others will have to work them out, though engineers may aid. If corporations could be protected from unfair attacks made by the ignorant or by persons looking for personal gain, the barriers complained of by Dr. Humphreys would be overcome, but that cure requires a long step forward. To make it, demands competent government supervision of all corporations dealing in a large way with the public, which imposes upon them, and upon utilities companies particularly, luminous public statements of their business; and it equally demands that the public shall yield justice to corporations with the same degree of completeness as the individuals of the public seek it for themselves. For accomplishing these two things we now have to rely to a considerable degree upon government commissions. If these commissions do not succeed in accomplishing these ends, they will be swept away and some other form of procedure put in their place; but for my part I believe they have it in them to succeed, and that various ones are succeeding.

As far as the public service corporations are concerned, they are the natural outcome of the demand of the civilized world for convenient transportation, rapid intercommunication and ready distribution of power. They compose a comparatively new and mighty force in the social order. Of course this force must be prevented from dominating or warping the social organization, but there is no danger of public service corporations becoming despots, as is now and then the apparent fear of some people, provided they are kept under proper restraint, and society cannot afford to make restraints which are of themselves unnecessary and unfair. These corporations serve a very beneficial end in our lives, and their rights are as well founded, and should be as well secured, as the rights of any citizens who are individually or collectively bent upon any proper business pursuits.

To further the cause of understanding, I will now lay before you six principles such as are referred to above, the general recognition of which would do much to give common ground for adjustment of differences of the nature that Dr. Humphreys complains of:

1. The company is granted certain special conditions by the public for the purpose of enabling it to furnish readily some type of service to the people, and it should be expected to furnish service fitting the needs of the people, good of its kind, and at prices which are reasonable when judged by the conditions.

2. The company must not be unnecessarily harassed by rules and regulations, but must be afforded every reasonable opportunity for economically transacting the business rightfully related to giving the service for which the company was organized; and it must be allowed to make such clear profits over all legitimate costs of its service that it may attract the best, fairest and broadest minds to the management, and maintain a position of stable credit with the investing public.

3. A public service company in a new and developing territory must see before it opportunity to earn returns on its invested capital which are large compared with those adequate in stable and thickly settled regions, in order that it may secure the capital needful for developing its plant and extending the service to meet the apparent needs of an expanding and not yet stable population. If opportunities for honestly earning large returns on the investment in a new territory are curtailed by legislation, the development of the service must inevitably become retarded, to the disadvantage of the territory and the inconvenience of the population.

In this connection it is pertinent to refer to the rate of ordinary interest in relatively new communities. Within two decades, for instance, the ordinary interest on bank loans with good security was ten to twelve per cent. in Colorado. Even now it is six to eight per cent. in Wisconsin.

4. A new project even in a stable territory ought to earn more than current rates of return for its investors whose enterprise prompts them to take the risks of establishing the business, but the return on the investment may be expected finally to come to current rates after the business has become firmly established on fixed franchise rights covering a long period.

5. A private corporation operating under a short-term franchise must have rates which are sufficiently high to provide an amortization fund which will reasonably insure the company's ability to return to the individual stockholders their original invested moneys in case the franchise is not extended. Otherwise, there is confiscation. A short-term franchise, unless accom-

panied by an agreement for purchase of the property at the end of the term, is therefore ordinarily not a provident grant for a public body to make; but a term franchise with an agreement to purchase the property if the term is not extended, or an indeterminate franchise such as obtains under the public service statutes of some of our states, is more to the advantage of the public since it makes a more efficient basis for conducting the business.

6. The bookkeeping for a public utility should scrupulously distinguish between capital expenditures and operating expenditures (including within the latter, expenditures for renewals of plant required to be made as plant depreciates in order that economical and good service may be maintained).

Mr. Stearns.* — Dr. Humphreys attacks the problem of reform and regulation from many points of view, but I think he makes it clear that he recognizes the necessity for the regulation of public utilities which are practically monopolies. He leads us to infer, however, that he believes that regulation as now conducted by legislative bodies is very bad, and that regulation by public service commissions differs from that by legislative bodies only in that it is less bad. He says of federal and state commissions, after referring to their good and bad work, " If a fair analysis were made of the complete record of their activities, I can hardly believe that the balance would be found in favor of the commissions."

I think all agree that regulation has come to stay until that far-away time when corporations will not ask for more than is justly due them and the people will not strive to award them less than their due; also that regulation by a legislative body must necessarily be defective because a legislative body has neither the time nor the qualifications for reaching equitable results in a matter which is so intricate as a regulation of public utilities. The practical solution of the question, therefore, is regulation by commissions.

It is hardly to be expected in a democracy that the members of commissions in all cases will be selected with reference to their fitness to deal fairly and equitably with the companies which they are to regulate. Some will unduly favor the public, and

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others the companies. My acquaintance with the work of public service commissions, obtained by reading their decisions in cases brought before them, by their technical discussions of subjects related to their work, and by personal contact, has led me to believe that in the great majority of cases they intend to be and are fair to the public service companies.

As I learn the claims made by public service companies in various cases, I am led to question whether the point of view of their representatives is not affected by the failure of the public service commissions to accept their inflated claims as to the value of the property in question. Some of the views expressed may be illustrated by quoting the decisions of public service commissions and by referring to the testimony brought before commissions and courts.

One of the fundamental principles definitely established by the United States Supreme Court is that a public service company should be permitted to earn a fair return upon the fair value of the property used by it for the convenience of the public. Although, under the law as laid down by the Supreme Court, the California Railroad Commission might have excluded an important property which was suddenly thrown out of service and was no longer used "for the convenience of the public," it made its decision on equitable grounds (3 Cal. R. C. R., July 29, 1913, pages 1051–1052):

"It seems fair, however, to permit the defendant during each of the ensuing ten years to collect rates high enough to permit it to charge off such sum on its books that by the end of the ten years the principal so charged off, together with the interest, shall have amounted to the entire value of the line at the present time. I believe that it will be very liberal on the part of the rate-fixing authorities to permit this to be done."

The Michigan Railroad Commission, in a decision as to the capitalization of certain lands purchased for a reservoir in connection with a hydro-electric plant, stated that it was "satisfied from the record that the sum of $500 000 would amply cover the cash outlay for the purchase of the land," but it took into account the long time (about eleven years) required to obtain the lands in a case where the company did not have the right of eminent domain. It also recognizes the various expenses incurred by the promoters, and permitted the capitalization of the land in the sum of $1 450 000, made up as follows (Orders and Opinions, Mich. R. R. C., Vol. 2, No. 1, page 25):

| | |
|---|---|
| Original land cost | $500 000 |
| Service in acquiring | 500 000 |
| Interest during purchase | 150 000 |
| Cost of promotion | 300 000 |
| | $1 450 000 |

Many other decisions made by commissions might be quoted to show their tendency toward liberal dealing without taking advantage of the technicalities of the law to diminish values.

One of the things which has led to the greatest difference of opinion between representatives of the companies and the commissions I believe to be the adoption of theories in common use in valuing the property by the cost of reproduction method. It is generally admitted that, subject to some exceptions, a property which has been built or acquired within a few years of the date of the valuation should have a reproduction cost and a value substantially equal to what the property cost, and this rule should apply not only to the direct cost of the property but to the overhead charges as well. Proper theories for determining overhead charges should therefore give results which will conform with actual charges in respect to recently acquired property, if not in other cases.

As illustrating cases where theories commonly used do not give this result, I will refer to a case where an appraisal was made in a given year and again five years later. One of the engineers who took part in the original appraisal brought it up to the later date by adding the expenditure for construction during the five-year period, as shown by the books, and made an allowance as an overhead charge for the interest during construction, which was not included as a construction charge in the book accounts. The allowance which he made was $48 000, which was practically the charge actually incurred in connection with the property built during the five-year period.

Another engineer, adopting the theory that in obtaining the reproduction cost the property should be considered as non-existent and to be reproduced in one construction period, found that the interest during construction equaled 8 per cent. of the total reproduction cost of the whole property, exclusive of interest. Applying this percentage to the part of the property built in the five-year period, the amount attributable to it was subtantially $152 000.

In connection with this same property, the item of "development expense" or "going value" was under consideration. One engineer adopted the view that the going value of the property at the later date of valuation was at least as great as five years before, making the allowance for going value on the property built within the five-year period practically zero, and this probably agreed fairly well with the actual development expense during this period.

Another engineer, estimating the going value in accordance with a commonly adopted theory, included $200 000 in the reproduction cost as the amount attributable to the property added during the five-year period. It is worthy of note that the evidence above mentioned was all given by engineers on the same side of the case.

When commissions are confronted with such varying evidence, it is not surprising that they adopt the figures which agree with actual expenditures in recent years, but this is likely to result in not well-founded criticism by those who believe that values determined by established theories should control.

Illustrations similar to those given above are furnished by two cases which were brought before the Public Service Commission of the State of New York, Second District. In one of these, Fuhrmann *v.* Cataract Power and Conduit Company (3 P. S. C. N. Y., 2 D., page 710), the Commission said:

"According to the witness . . . the cost, as it might be termed, of acquiring the business of the phantom plant was $1 000 000. Apportioning this cost to the business acquired during the last five years, we find that upward of $500 000 of it is assignable to that period, while the expense actually incurred was $34 004. It may be answered to this that the expenses were incurred during the previous history of the company. There is nothing, however, to show that this is the fact, and an analysis of the accounts of the company would show that it is not a fact."

In the second case, that of Fuhrmann *v.* Buffalo General Electric Company (3 P. S. C. N. Y., 2 D., page 739), the Commission reproduces a table (page 749) which was prepared by a witness for the company as an estimate of the cost of reproduction of various parts of the physical property, which gave in detail the overhead charges applicable to each part. From this table the Commission selected for illustration 3 000 municipal arc lamps, purchased after the company had been in existence for years. Its tabulation of the cost and overhead charges is as follows (page 750):

| | | |
|---|---|---|
| 3 000 municipal arc lamps at $21.70 | | $65 100.00 |
| Engineering and supervision, 5% | $3 255.00 | |
| Organization of business, 6% | 4 101.30 | |
| Taxes and interest during construction, 4% | 2 898.25 | |
| Piecemeal construction, 10% | 7 535.45 | |
| Promoter's profit, 5% | 4 144.50 | |
| Brokerage, 1⅔% | 1 453.46 | 23 387.96 |
| Total | | $88 487.96 |

The overhead charges in the table amount to 36 per cent. of the estimated cost of the property units, and do not include going concern value, for which the company claimed a large sum.

Commenting on the overhead charges, the Commission said:

"We are unable to understand, and no explanation has been offered us, why a company which has been in existence for years should be entitled to charge a promoter's profit of 5 per cent. upon new arc lamps which it buys for its service. We are also unable to understand why a 10 per cent. charge, amounting in this case to $7,535.45, is proper for piecemeal construction in the case of buying 3 000 arc lamps at one time."

It seems clear that theories which give values far in excess of actual expenditures will be given up when valuation matters are better understood; but in the meantime they support inflated claims, and much hard feeling is engendered because these claims are not recognized.

Dr. Humphreys presents the view that the deduction of depreciation from the value of a plant in rate-regulating cases necessarily means confiscation.

In any continuous system of regulation such as now prevails in the case of railroad, telephone and many other companies, the equitable treatment of depreciation requires a consideration of the amounts that the companies are permitted to earn and required to set aside to cover the lessening value of their perishable property.

The fundamental principle relating to depreciation in connection with such regulation is that the company, in addition to being permitted to earn a fair return on the capital invested in the property, shall also be compensated for the loss of capital value due to the depreciation of the perishable property as it grows older. Various methods of accounting for this loss of value have been adopted and are now in force under the authority of the public service commissions.

In railroad accounting in the past, and to a considerable extent at the present time, the theory has been that sufficient rates shall be earned to compensate for the loss in the value of property units at the time they cease to be useful. Under this theory the rate payer is not supposed to furnish any compensation for the loss of value of a property unit as it accrues, but to furnish the full compensation at the time it ceases to be useful. This is known as the replacement method of compensating for depreciation.

In the case of the telephone companies, the prescribed accounting methods are different. The companies are required to make depreciation charges each month or year "to cover the expenses of depreciation currently accruing in the tangible fixed capital," and it is required that the rate of depreciation shall be so fixed "as to distribute, as nearly as may be, evenly throughout the life of the depreciating property the burden of repairs and the cost of capital consumed in operations during a given month or year, and should be based upon the average life of the units comprised in the respective classes of property."

The amounts which these companies are permitted to charge as a depreciation expense is a recognized factor in determining the rates which the public must pay, and that these amounts are not small may be seen by reference to the Annual Report of the Directors of the American Telephone & Telegraph Co. for the year 1915. This report gives a combined statement for the Bell Telephone System in the United States, and gives items which in round numbers are as follows (page 11):

| | |
|---|---|
| Current maintenance | $31 000 000 |
| Depreciation | 45 000 000 |
| Total | $76 000 000 |
| Payments on account of interest and dividends | $51 000 000 |

It will be seen from this statement that in addition to the expenditures for the current maintenance of the property there is a depreciation charge of $45 000 000, which is well up toward the total amount paid by the company on account of interest and dividends. This sum of $45 000 000 per year is compensation for the depreciation accruing during the year in the perishable property then in use. It is a much larger sum than is required for the renewal of the property units which have reached the end of their life in that year, and there is a great sum of money which can be invested in additions to the plant. The plant therefore is built up to a very considerable extent with money furnished by the rate payers, and if the property were to be valued on the basis of the cost of reproducing it, without deduction for depreciation, the rate payers, if required to pay a fair return on such value, would be paying rates on the money which they had contributed to the building up of the property. This clearly would be inequitable, and there should be a deduction for depreciation so that the value of the property would more closely represent the investment made by its owners and not by the rate payers.

In the case of large parts of a railroad property the conditions are very different, because the systems of accounting used in the past and now used to a considerable extent are based on a theory which does not require the rate payer to contribute monthly or yearly the amount of the accruing depreciation of the existing items of property. It would be inequitable in such cases to deduct depreciation from the cost of reproduction of such property.

The subject is a complicated one, and cannot be made clear in a short statement, but there can be no question that from an equitable point of view the deduction or non-deduction of depreciation must depend upon the system by which the rate payers are required to contribute for the depreciation of the property.

In this connection it is interesting to note the viewpoint presented by the eminent counsel of the railroads in the brief filed before the Interstate Commerce Commission, page 163. It conflicts with the axiom which all engineers have learned in their early days, that "the whole is equal to the sum of the parts."

> "The gradual lessening of the service life of a simple property, whereby there must eventually be a complete loss of its service life and its replacement as a whole, is depreciation in it; but this lessening of its service life, where it is but a part of a composite property, is not depreciation at all in the composite property."

Dr. Humphreys suggests a comparison of the fruits of individual enterprise with those of government ownership and management, and adopts a view unfavorable to government ownership. There are too many cases of successful government ownership and management to permit their indiscriminate condemnation. Such ownership and management has in general proved very successful in connection with water supplies in New England, and the Metropolitan Water Works of Massachusetts may be referred to as an instance where the results could not be approached by the same public works under private management.

The actual cost of these works to the end of the year 1915 amounted to $42 800 000. The water is sold to the cities and towns in the Metropolitan Water District at cost, and in 1915 the total charge for interest and an adequate charge for depreciation was $1 747 000, equal to 4.08 per cent. of the cost of the works. In addition, there is a charge for operation and maintenance of the works of $417 000, amounting to 19.3 per cent. of the gross earnings, which would be reduced but little, if any, under average corporate management. The total charge against the consumers was, therefore, $2 164 000, which is only 5.06 per cent. of the original cost of the works. Such a result could not be achieved or approximated under private ownership.

MR. WEED.* — I feel very much like making an apology to-night. In the first place I am a lawyer, and in the second place I am a regulator. After hearing this paper, I believe that both of these occupations are of questionable character. I belong to a little neighborhood club where we try to read papers to each other and discuss them, and it is one of the traditions of the elders of the club that we shall say no good of any paper. Their theory is that it is far more wholesome for the soul to meet with indiscriminate criticism than with indiscriminate praise. Of course, for that matter, Dr. Humphreys' abilities are too well-known and too conspicuous to require any praise from me.

I have the advantage of many of you because I was entrusted with a copy of this paper a day or two ago, and I had a chance to read it in cold blood without that subtle charm of personality which so often carries us along in unconscious and unreflecting sympathy with the views of one who is addressing us.

If you followed the paper in the same way that I did, I think you must have been impressed by a persistent note that the public service corporations of this country were being wronged and were suffering grievous injury at the hands of an overdeveloped and unwisely conducted regulation and by a false democracy. I was reminded when I read it of my childhood, when "Pilgrim's Progress" was not entirely out of fashion. It seemed to me that we had exhibited in this paper the public service corporation in the disguise of Christian, struggling over the long, toilsome, difficult road to Mount Zion. As he climbs the steep slopes of the Hill Lucre, there are two monsters ready to devour him, — Regulation and Democracy. Fortunately, however, Greatheart, in the disguise of an engineer, is also there ready to slay the monsters.

* Chairman, Board of Gas and Electric Light Commissioners of Massachusetts.

I do not suppose Dr. Humphreys intended a distorted or exaggerated view of the conditions which he has described, but when one sees a danger which he believes menaces and sees it keenly, I think perhaps he is very apt to give a pretty emphatic view of that danger, and not always to exhibit with the same care some other equally threatening dangers. I cannot help thinking, too, the more I hear about regulation, — and I have to hear more or less about it, — and a great many uncomplimentary views of it besides, — I cannot help thinking that there is a great deal of real misapprehension about its purpose.

I should like to say by way of introduction, though I know it is rather dangerous to generalize because the foundation for a sweeping proposition is often extremely superficial, — but, since we have heard something about the dangers of a false democracy, I should like to suggest that the continued existence of unrestrained monopoly is utterly inconsistent with true democracy. The philosophy of regulation, if I understand it, and I do not know that I do, although I have a great many instructors and some of them are present to-night, — seems to be based upon the consideration that certain evils are commonly attendant upon monopoly. These evils are so persistent and well known that we no longer have to discuss the probability of their presence. That is taken to be self-evident and rests finally on the fact that human nature is still somewhat unregenerate. And in acting upon this premise I take it that really we are merely judging others by ourselves and expecting them to do what we would probably do in their position.

Regulation is merely the means employed to check or correct the evils which we know or expect will attend monopoly. Simply because monopoly is deliberately and legally created introduces no good reason why we should not expect the same evils to be present as if it were illegally asserted. We are trying to restrain and check these evils by regulation, — restoring the equilibrium of which Dr. Humphreys has spoken. Perhaps I have too great confidence in human nature, but I believe that in the end those evils will be diminished and perhaps wholly eliminated. And I think that point of view of regulation and its possible effect does not have enough emphasis, — is not so prominently discussed.

I suppose that those who have had any personal experience in administering regulation will be quite as quick as any to admit the correctness of some of the statements which have been made. I think we must all agree that there has been a certain tendency throughout the country to over-develop regulation. I am also in hearty agreement in believing that the federal valuation of railroads is one of the most monumental pieces of folly ever undertaken, with its principal value in sharpening the wits of those engaged in it. It may be true that it was forced upon the railroads through misguided regulation and by false democracy, but I think the railroads themselves perhaps had as much to do with it as the Interstate Commerce Commission. No right-minded person, even though he be a regulator, but desires to see the public service corporations strong and prosperous, so that they can take a black eye or a bloody nose in a bout with Regulation without suffering a mortal wound. But I dissent from ascribing all the ills of the railroads to Regulation and Democracy. Certainly we know better in Massachusetts. After all, what I am really trying to point out is that Regulation is not an end in itself but merely a means, an incident in the attempt to control monopoly. I have a strong notion, too, that the public service corporations have largely in their own control the style and fit of the clothes in which Regulation is dressed.

In spite of the danger of laying down broad propositions, I venture to say that the essence of a true democracy is the virtue of its individual citizens. My own conception of the citizens' duty is that there shall be a spirit of cöoperation rather than of hostility. Dr. Humphreys himself alluded to this. In the true democracy, each citizen must willingly assume his full share of the burden of the public welfare without conditioning his action upon that of others. In France and England, where we have heard and know more about conditions among the people of the nations at war, I think that we all have been impressed by their wonderful spirit of self-denying devotion to the common good. We might well take from it a very serious lesson to ourselves. As far as I can see, they are exhibiting the true democracy. There can be no "slackers" in a true democracy. If the public service corporations do not fancy these monsters, Regulation and Democracy, might it not be well for them to set the example of the self-denying citizen in the true democracy? When they have become so virtuous that their virtues shall shine forth and be known of all men, Regulation will cease, and the public officials with their sometimes over-developed staffs and organizations who administer it will pass away. They only exist because certain evils exist. When those evils cease to exist, they will have no longer any reason or right to exist, and we will all be glad to see Regulation go. We are looking forward to that time.

Personally, I feel like being an optimist, pressing on as far as may be possible in the present and hopeful of the future. I heard, by the way, a new definition of an optimist the other day, which I will give you in closing. It was on the occasion of a visit to our office of a cross-eyed man. Some one suggested that an optimist is a cross-eyed man who thanks God that he is not bow-legged.

Mr. Snow.* — I am very glad to see the absurdities and actual errors of our regulating bodies shown up as the author of the paper has done. Our regulation and control of public utilities has been at par with much of our governmental actions, federal, state and municipal. Our ultra-democracy has led into irrational situations.

Our fear of hereditary and royal privilege, born during the reign of the Stuart kings of England, has followed our race to this day, and has left us still afraid to trust continuous power in the hands of a single governing authority. The result is special commissions for nearly every administrative function, and great confusion of executive, legislative and, to some extent, judicial departments of government. The lack of an authoritative federal ministry has led to the usurpation of legislative direction by our Presidents to an extent that should shame a republic.

Our city governments have been a national disgrace for a century, but a better day is dawning. The charter lately adopted by Ashtabula, Ohio, portends, in my opinion, the most perfect

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city government that the world has ever seen, — a legislative ministry elected by proportional representation and a king appointed during good behavior.

The way that our author slams state commissions is good to hear. Their flounderings are but natural, however, to their origins, their environments and their implied instructions. Their blundering attempts at railroad regulation as set forth by Mr. Alfred P. Thom in the paper show how our democracy has run wild. In a few years forward, this condition will be looked back upon with the same kind of indulgence and pity for the ignorance of our period as we feel when we look back upon the Ohio legislation which prescribed a different gage for railroads in that state from the gage obtaining in adjoining states, with the idea that the transfer of everything at the state line would create business for Ohio's citizens. The logical, and I think, inevitable solution is a unified federal control of all intra- and inter-state traffic.

The parent of governmental control of American railroads was competition between them. This led necessarily to regulation of rates, which in its turn called for valuation of the operating properties. The hardships to which the roads have been subjected are the natural outcome of the breaking in of a green team by a green driver. More settled conditions are becoming apparent, and, moreover, the suffering which stockholders and managers have experienced is slight punishment for the reckless and selfish use of their power and opportunities in the past.

Ideal regulation is not easy of practical application in the present state of human ethics. The line dividing so-called public utilities from private industries which sell their output to the public is very indistinct. The range covers all the space between agriculture and the rankest monopoly. We have industries that are wholly competitive, those which are wholly monopolistic, and those of all shades between these extremes. The problem of regulation is the simplest when applied to a pure monopoly, but in this case, even, what shall be the result aimed at by the regulating body? What is the proper objective of the operation of a public utility? The financier will say, to return the highest dividend possible on the investment; the stock speculator will say, to alternately shrink and swell the net earnings so that the price of stock may oscillate; the altruist will say, to so handle the operation that people and goods may be transported at the lowest possible rates; the general officers may say, to bring the greatest possible glory and renown to them; the union employees may say, to give employment at the highest possible wages to the largest possible number of men; the courts say, "On the one hand, we have the plain duty of the corporation to furnish suitable and sufficient service to the public and on the other, the equally plain necessity of providing a fair return on the capital necessarily invested in the enterprise." The regulating official must contend with all these clashing interests in reaching his decision. It is no easy task.

I am interested in the author's interpretation of "depreciation." He states that the liability for subsequent renewals, erroneously called "depreciation," is not the reduction in worth as reviewed by a possible purchaser, but is the accrued liability of the owner. It is hard to see why the owner's liability should not pass to the purchaser, and, if it does, why it should not decrease the worth, as compared with value new, by the amount of the liability. The fact is, there are two fallacies covered in the statement; first, the capitalized prospective net earnings modified by the physical condition of the property above or below normal condition, measures the amount that a purchaser will pay, and hence deferred maintenance and not depreciation is what he inspects; and, second, the cost of renewals is a liability of the public and not of the owner. If the said cost is not charged for until the item is renewed, or if an annuity only is charged which kept at interest will amount to the cost of the item at the end of its life, the owner is simply waiting for the payment of his principal like the holder of a promissory note, and in these cases nothing should be deducted from value new when computing present value. If, on the other hand, annual sums have been charged for depreciation, and have been met by the earnings, which aggregate the full value of the item considered, then the accrued returns for depreciation should be deducted. The matter of deduction is simply a question as to whether or not the owner has been paid accruing depreciation in a way that he can use as wholly his own, or whether it is held in escrow by the public or a trustee until the passing of the item. This is the crux of the whole science of depreciation.

MR. THOMPSON * (*by letter*). — The writer was interested to hear the paper on " Reform and Regulation " as coming from one with extended experience in the management of public service corporations. However, disappointment in the address must be expressed, as it presented no constructive plan and gave so few suggestions of a constructive nature. Starting out with the proposition that, " on the one hand, quasi-public corporations should be required to submit to regulation under government authority," the author neglects, it appears, to treat this phase of the subject, but confines himself to a statement of the ill-effects of over-regulation. He states as the two fundamental conditions which limit the regulation of our public utilities that the initiative of the corporations should not be destroyed and that public service commissions should not be permitted to exercise the three functions of government. Assuming that this be true, what is the foundation of the public service corporation, and how should it be exercised?

The author brings out many very true points with reference to unfair treatment of corporations and biased commissioners. From the standpoint of one associated neither with municipal work nor with public utility service, it would appear that the very fact of monopoly implies the necessity for regulation. The spirit of the public during the last two or three years has undoubtedly been too severe, but, as is practically acknowledged by the author, this was brought upon the public service corporations by the action of certain of their number, and there is at least a question whether the number of these was comparatively few or whether the tendency was not widespread. Until human nature is changed, until we have a control of business based not on money returns but on the Golden Rule, we cannot expect groups of men with private interests to work directly for the interests of those to whom they are selling their product. It

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seems scarcely logical to take the position at least implied by the author of "Hands Off."

If a regulation, then, is necessary where monopolies are in operation, how shall this regulation be applied? How shall we have the coöperation between the two parties, as suggested by the author? What shall be the basis for regulation? What rules for capitalization (to which I see no reference in the paper) shall be evolved? On what basis and by whom shall rates be determined? These are pertinent questions, and it is to be hoped that Dr. Humphreys in his closure will present constructive suggestions on reform and regulation.

Dr. Humphreys.* — I would like to repeat the first paragraph of my paper: "It is practically impossible to discuss any question of importance without being misunderstood. Those who strive to preserve the balance between two extremes are almost always sure to be misunderstood by the adherents of both extremes."

I am in the habit of saying, in lecturing to my classes (some of you perhaps think I am an educator by profession, which I am not), that if I should be speaking to a class of 85 on any open question there would be 85 different opinions as to what I had said. To-night gives another rather striking example to confirm the opinion I have held for many years. It is true that I have not been taking an optimistic view about democracy, nor have I been making any argument against democracy. On the contrary, I have been endeavoring to point out that if we are to enjoy the advantages of democracy we must pay the price; but I have said it was our duty as citizens, and especially our duty as engineers, being involved in all the activities of life, to endeavor to keep that price down to the lowest limit.

In preparing this closure I have read carefully, critically, my paper and the discussions submitted at the time my paper was read, and the written discussions submitted later. In all of this discussion I find little which has not been answered in advance in the paper itself. But, in view of the misunderstandings which are apparent in the discussions and as anticipated

* Author's closure.

in the opening paragraph of the paper as above repeated, I shall take up some of the points made by those who have been good enough to take part in the discussion, and I shall make an attempt, largely by paraphasing, to remove some of the misunderstandings.

Coming down to a few of the points raised in the discussion, — I am glad to find that in the main Professor Jackson agrees with me. I do not think I can agree with him as to the evils I mentioned passing away, and that the day will come when the troubles we are now talking about will be forgotten. It is this very optimism, when carried to an extreme, that increases our troubles; we are too prone to allow ourselves to be led away by the smooth-tongued orators of the Bryan type who succeed in impressing upon the uninformed the idea that we must be intolerant of everything that is not ideal. We have got to make up our minds that conditions that are not ideal will continue to exist; *but it must be our constant effort to limit where we cannot eliminate the evil.* In my opinion, the millennium is not here, and will never come in this world. If you call that pessimism, then I am a pessimist, — but I do not believe that I am.

Professor Jackson says that commission government is young. "In certain few of the states, commission control of the public service companies has been in vogue for several decades, but in most of the states it has been a matter of but few years." He then takes the ground that some that are old are "fairly conservative," while others are "younger and less conservative." Unfortunately, my observation does not indicate that the older commissions have grown more "conservative" with age, but just to the contrary. The Gas and Electric Commission of Massachusetts is the oldest of the gas commissions, and, certainly, its practice has not become more "conservative" with its increasing years. The contrary is the fact. In some respects it is now one of the most radical of our state commissions. Furthermore, as I have indicated in my paper, *as a general proposition*, the commissions reach out for more power and become more and more arbitrary in their practice as their years increase.

With regard to those 626 000 stockholders, — and I find my figure agrees with that of Professor Jackson, — we must not forget that with regard to the general interest throughout the United States in our industries and especially in our railroads (because it is railroad securities that are so largely purchased and held by the insurance companies and the banks) there are eleven million depositors' accounts in our banks and forty millions of life insurance policies; and that is why I made the point that it is a hopeful sign that the people themselves are beginning to be alarmed. We must hope that these depositors and these policyholders will make their influence felt if conditions become so bad as to decrease the rates of interest and increase life insurance premium rates. "Whose ox is gored?"

I am not sure that on another point I can agree with Professor Jackson in regard to the reliance to be placed relatively upon the consulting engineer and the operating engineer. Here again I am going to be misunderstood. There are consulting engineers and consulting engineers. I believe one of the troubles of the consulting engineer in his work is that he is apt to forget his experiences as a constructing and operating engineer — assuming that he has had such experiences. He must have been a constructing and operating engineer to be really a consulting engineer. I do not believe that men who are acting as consulting engineers and who have not had real practice in the management of properties and *been held responsible for the money results* are safe consulting engineers. I know we consulting engineers should constantly be prepared to resist the temptation to forget what were our responsibilities when we were held accountable for the money result. It is my experience that the administrative engineers throughout the country, who are operating the various great properties, are coming to understand more and more the money responsibility connected with the work of which they are in charge, and I believe as a class they are the most competent in that particular line, far more so than many of those who advertise themselves as consulting engineers.

With regard to the work before the public service commission, what I have been objecting to is not the good work that has been done. Of course not. It is the unfairness that is so much in evidence. I have, just as Professor Jackson has said he has, intense sympathy with the man who is trying to-day to do his work under the conditions — the tremendously difficult conditions — under which a public servant has to work. I know some men to whom I look up with the utmost respect for the work they have done in that capacity; but what I object to — and I say that it is not only our right but our duty to object to it — is the unfairness and lack of judicial quality exhibited in the acts of many individuals connected with the public service commissions, and not unfairness through accident but through deliberate intention; and I make this charge knowing that it cannot be fairly refuted by those who have had personal experience in commission hearings; and I say again that I have the utmost sympathy with those exceptional men who have done their full duty in the face of bad examples.

Professor Jackson expresses the opinion that if the public service commissions do not accomplish what is fair to corporations and public "they will be swept away." I find little encouragement for this optimism in the records of our politicians.

With regard to Mr. Weed's remarks, there is not a word in my paper which shows that I have the slightest disrespect for the profession of the law as such. On the contrary, I have stated that every commission should have at least one member who is thoroughly up in the profession of the law: but there are lawyers and lawyers. I do believe, however, *that the profession of the law is over-represented in these commissions.* My advice to our young men about to graduate (and we give them some instruction on partnership and commercial law) is that they should use their necessarily superficial knowledge of law in finding out what to avoid, and also to make them extremely careful in the selection of their lawyers.

I believe — and I know I am not speaking from prejudice — that in very many cases the corporations have been greatly wronged in the decisions and opinions of the commissions.

With regard to regulation and democracy, I believe absolutely in both. Apparently I am understood as not believing in either, because I point out evils to be avoided as far as possible. As to the weaknesses in regulation by commission, I do not believe I have exaggerated in a single instance. I could give cases so much worse than those I have cited that you would be justified in thinking I was exaggerating. Mr. Weed refers to the dangers of unrestrained monopoly. I do not think there is such a danger, because there is no apparent chance for unrestrained monopoly in this country, — certainly not with regard to public utilities. There never was unrestrained monopoly on the part of public service utilities before the day of regulation save in most exceptional cases. On the contrary, there was the widest and most reckless competition. Take for instance the little town of Yonkers; at the time when there were only 15 000 inhabitants, there were four independent gas companies fighting each other for the small business there to be found. New York was one great field of competition, so was Baltimore, and it was the same all over the United States. That was our trouble. The public and the investors have suffered more from *competition encouraged by our politicians* than they have from monopoly. "Human nature is unregenerate." That is the point I have been making. Mr. Weed and I agree on that, and it is because it is unregenerate that we have to bear it in mind so that we shall do our best to regenerate it. But we are not going to do it by listening to those enthusiasts who tell us that in a few years we shall eliminate the present weaknesses and evils of regulation as generally practiced. It is for us to face the fact that the present tendency is to exaggerate the evils of which I have spoken. One natural corrective of monopoly on the part of public utilities is the competition among themselves which continues to exist and must so continue. For instance, the competition between manufactured gas, natural gas, and electric light. In one city in New York State there is the most active competition between the three companies furnishing these three lighting services. As president of one of these companies, I know whereof I speak. This competition would exist, regulation or no regulation. The trolley lines now have active competitors in the jitneys, and so it ever will be. I have seldom met a commissioner who would admit that such competition has to be reckoned with.

Mr. Weed says there has been a tendency to over-regulation. I certainly agree with him there. That is my text. There has been a great and increasing tendency toward over-regulation, and this is threatening the very life of our public service corporations to-day. Professor Jackson, on the other hand, apparently thinks that conditions are improving in the application of regulation by commissions. I wish I could agree with him, but I cannot. I can see no hope for improvement so long as the tendency is towards over-regulation by placing more and more power in the hands of the commissions as to *details of management*. The first remedy is to limit the powers of the commissions so that they shall not exercise authority in the three functions of government, — the legislative, the judicial, and the executive. "My own conception of the citizens' duty is that there shall be a spirit of coöperation rather than of hostility," Mr. Weed said. Again I agree with him, but I believe absolutely that the corporations, now taking the average, have been far more honest and have shown a far greater spirit of coöperation in the efforts to make regulation a success than have a majority of the commissions. Let me refer to the case of a member of the Public Service Commission, Second District, New York, — the same commission to which I have referred before. This man had been successful in business, was a man of means and desirous of serving his fellows unselfishly. I testified before him a number of times and was impressed with the fact that while he wanted to be fair he was very strongly prejudiced against all corporations. From time to time I was before him throughout the five years of his term. As time went on I found that in talking to me he would express surprise that the testimony given for the corporation seemed to be fair, and that we had shown no objection whatever to bringing out the facts exactly as they were. About three months after his term expired, he was making an address in the neighborhood in which he lived and he made this statement in the most emphatic way, — that he went into office as a public service commissioner believing that the corporations were making every possible effort to deceive him and certainly were not coöperating to develop the facts; and then he said: "I am forced now to say in all fairness that as a general proposition the corporations which came before me showed a far greater inclination to be fair and to coöperate with the commission than did the representatives of the cities."

The evils to which I have referred in my paper are always going to exist to some extent, as far as I can see, and my thesis has been to keep the facts before us all the time, so we can be prepared to reduce these evils to a minimum. In my own work with the commissions I have from the first done everything in my power to make it easy for the public service commissions to develop the truth, the whole truth and nothing but the truth. I remember in one celebrated case the lawyer for the complainants had rather crude ideas as to courtesy, with the result that at first we did not get along together very smoothly. Before we got through with the case he was in the habit of coming to me to consult me as to his side of the case, and I was glad to have the opportunity to discuss the facts frankly with him.

With regard to Mr. Stearns's remarks, — Yes, regulation is necessary. Of course the liberal spirit is shown in some cases by the commissioners, — that I have said, — and a most illiberal spirit in many more cases. I do not think it does any good to bring up a few cases on either side and say that the general result is thus determined. I have guarded myself very carefully in my statements by saying there are some cases on one side and some on the other. With regard to the theories of engineers, it is our business to correct those theories. I am talking to engineers, but I am not saying anything in support of the engineers *as against the commissions* with regard to these theories. I have not introduced that point except very briefly in connection with depreciation, and on this vitally important subject engineers of prominence disagree. I am objecting to the fact that the commissions in many cases go out of their way to be unfair in their consideration of the important questions brought before them for judgment. I am not objecting to honest differences of opinion on questions of theory. Let the theory be what it may, it is the duty of the commissioners to see that the testimony put upon the record is complete, — the truth, the whole truth and nothing but the truth; and I say without fear of successful contradiction that, in two thirds of the cases I have been interested in, *no such effort has been made by the commissioners.* I will go further and say that in many cases in which I have been concerned the presiding commissioner has done his best to cloud the record. I say this fully recognizing the seriousness of the charge. There is room, and always will be, for differences of opinion, but they should be honest differences of opinion. Of course there will be testimony by engineers that cannot be supported. Otherwise we would be claiming that we are all perfect in our profession. Certainly we claim nothing of the kind. But that does not say that because some engineers advance incorrect theories the commissions should give the corporations unfair treatment. We should strive to be fair on both sides. It is for the commissioners to do their best to analyze fairly conflicting testimony. This they too often fail to do. Because certain unfair or stupid claims are made for the corporations does not give a valid reason for assuming that the corporations are unfair as a class. I would like to make one suggestion in regard to Mr. Stearns's remarks. Is it not true that the value of an inventory of a property as it exists is over-emphasized in most of the commissions? I would like to ask the engineers present who have had to do with real work, Does an inventory of existing work adequately represent the money that has been put into that work? Would an inventory of the completed subways of New York as being built to-day, after they have been built and everything was listed that you could find, — would such an inventory of plant and equipment represent the money invested in that property? Take some of the men here to-night, — gas men who have had difficulties with obstructions in the streets, — is it not true that in many cases their estimates, based upon average conditions, would not begin to pay the cost by reason of the local and special obstacles met? I know of a case in New York City of an able and conservative engineer who was imported from the West and who made his estimates on the cost of laying of pipe based upon the conditions in smaller and more open western cities, with the result that the work in New York City cost three times his estimate. And yet the schedule of the pipe would show so many feet of the several sizes of pipe, and the obstructions and contingencies would not and could not be adequately reflected in the inventory.

Mr. Stearns accuses me of "indiscriminate condemnation" of government ownership and management. The characterization is not warranted by the contents of my paper. My point is that, as a general proposition, — exceptions rather serving to prove the rule, — government ownership and management in this country is not as efficient or economical as private ownership and management. The one case cited by Mr. Stearns has the earmarks of an exceptional case. But even in this case we are not told that any allowance is made for the taxes which would be paid into the public treasury under private ownership and which are lost to the government under public ownership. I have examined in detail the accounts of not a few government-owned properties which made an admirable showing until examined competently. The result of such examination in *every case* in my experience showed that the comparison with privately owned properties was unfairly made. In not a few cases, this examination showed gross misstatements of the facts. This may to a great extent be covered by the one word, — politics. Certainly, with those who have had any real experience throughout the country, with the financial operations of politically governed undertakings, it should not be necessary to say much in support of my position. If there are any not convinced, I can only say: Go out and get a little more experience, sad experience, with politicians.

I am glad to note that Mr. Snow agrees with me as to " the absurdities and actual errors of our regulating bodies." With Mr. Snow I am willing to hope for better things, and especially through unified control. Just how unified control can be secured in the face of state rights, I confess I am unable to see. We are not likely to secure better results by entertaining a pleasant belief to that end while we should face the fact that the commissions are usurping more and more power in connection with the should-be-independent three departments of our government.

In regard to " depreciation," I am sure Mr. Snow has misunderstood me, and the fault is partly mine for attempting to discuss such a difficult subject in so few words. But the little I have said might well be read again, and particularly as to the differentiation between a " reserve . . . to spread the cost of renewals uniformly over the years of service " and " real depreciation of plant . . . *the plant in meantime being maintained thoroughly*."

Mr. Snow quotes me as saying, "He states that the liability for subsequent renewals, erroneously called 'depreciation,' is not the reduction in worth as reviewed [viewed] by a possible purchaser, but is the accrued liability of the owner." Mr. Snow then goes on to say, — "It is hard to see why the owner's liability should not pass to the purchaser." Of course it passes to the purchaser, if the property changes hands. The purchaser will trade on the amount to be deducted from the purchase price new because of the liability he assumes, and, if he is wise, he will not accept without careful examination the seller's estimate of accrued liability for plant not yet to be renewed. Particularly should the estimates on accrued liability for future renewals not be based upon tables and mathematical computations. Only by *competent* examination in detail can the remaining life of the parts of a plant be estimated with any degree of accuracy. It is unfortunate for our profession that not a few engineers have encouraged accountants and commissioners in the belief that such estimates can be made by reference to textbooks and the employment of average figures. Such practice may be mathematics, but it certainly is not common-sense. There is no line of work in which experience as constructor and operator is more necessary. How can a textbook giving *average* figures instruct one as to operating conditions in a particular plant, conditions which may so vary as to make it absurd to assign the same life to two boilers of the same type, delivered from the works at the same time? I have assumed that there is no deferred maintenance, in the sense of renewals and repairs not made when they should have been made. In the statement which Mr. Snow has quoted from my paper, I intended to make the point that this assumption of liability which a possible purchaser would regard as a reduction in worth or value, and hence to be allowed for in the price to be paid, should not be the view-point of the commission in connection with a rate case involving the problems of investment and present value. If the property were sold, the liability to renew the plant would still rest upon the owners, whoever they might be.

So much for the first of the " two fallacies " which Mr. Snow has discovered in my statement. The second " fallacy " seems to be based upon Mr. Snow's contention that " the cost of renewals is a liability of the public and not of the owner." I presume Mr. Snow bases this rather radical proposition on the assumption that the cost of renewals is to be included in the rates for service. Then why not deduct for all charges on account of maintenance, including current minor renewals and repairs as well as the renewal items included in the estimate of renewal reserve? Again, suppose the rates are not sufficient to cover total maintenance and a fair return, who is liable then? Those of us who have operated public utilities know to our cost that the rates are too often insufficient in this regard. Particularly is this so in the early years of such enterprises; and, generally, it is getting to be harder and harder to induce the commissions to acknowledge that the rates (" the public ") should bear this full cost.

As I understand Mr. Snow, he agrees with me that renewal reserve should *not* be deducted " if an annuity only is charged which kept at interest will amount to the cost of the item at the end of its life." There goes the other fallacy, for, I hold, that is *the* way a renewal reserve should be estimated and maintained. This does not preclude carrying a further reserve for contingencies; but that is another story.

If Mr. Snow and others are interested in my views on this most important and much misunderstood subject, I refer them to some of my other papers as follows:

" Depreciation: Estimated and Actual." Presented before Institution of Gas Engineers (Great Britain), 1913. Reprinted in U. S. in *American Gas Light Journal*, September 15, 1913, and also in pamphlet form.

" In Rate-Fixing by Commission, Should ' Depreciation ' be Deducted from Plant Valuation?" Presented before American Gas Institute, October, 1914. Reprinted in technical journals and in pamphlet form.

" Discussion of the Report of the Special Committee of the American Society of Civil Engineers on Valuation of Railroads and other Public Utilities for Rate Making." *Proceedings* of A. S. C. E., August, 1914, page 2013.

This subject is also discussed in many other of my papers, including the paper entitled, " Public Utilities," presented before the International Engineering Congress, San Francisco, 1915.

Mr. Thompson finds fault with my paper (and Professor Jackson expresses regret) because in it I give "so few suggestions of a constructive nature." Even if that were a fact, I should not feel that it were necessary to make any defense, for an accurate diagnosis should precede an agreement as to the most effective remedy. This discussion furnishes an illustration, for certainly we engineers have not come to an agreement as to the diagnosis.

But I have ventured to make some rather important "constructive suggestions"; one being that the scope and authority of commission control be reduced rather than extended and increased. Especially I suggest that the commissions be not allowed to exercise the three functions of government, which by our written and unwritten law, endorsed by party platforms, should be kept separate and apart. In this connection, as showing that the party now in power does not consider this a dead letter, I have quoted from the 1912 Baltimore platform of the Democratic party. If this is a sincere expression of principle, let the activities of the commissions be confined to legislative functions. Certainly let them be debarred from exercising executive or judicial functions. Until the commission statutes can be amended, I suggest to the commissioners, even if they are not naturally inclined to be judicial, that they at least endeavor to cultivate a desire for ordinary fair play, and so, during the hearings at least, give to each side equal opportunities to develop the facts. I would further suggest that if they find themselves unable to go so far — namely, to abstain from such indecorous exhibitions of partisanship during hearings — that they at least refrain from side remarks with their associates and assistants, intended, apparently, to indicate contempt or amusement in connection with the testimony being offered by the witnesses for the corporations.

Since I delivered my address, I have been attending at a hearing where the commissioner conducting it was guilty of flagrant misbehavior of the character I have just indicated. That it may not be thought that I am influenced by personal feeling in these criticisms, I will say that I am confining my statements to cases in which I have been an observer and not an actor.

In view of our pronounced liking for the multiplication of laws, I hesitate to make any suggestion in that direction; but I would suggest the amending of existing public-service commission laws by relieving these commissions of all authority and all responsibility in connection with the executive and judicial departments of government. There need be no fear that cases for regulation would then not be brought before the commissions in the absence of their initiative as executives, for complaints are easily formulated by the ratepayers under the laws in force. No matter how efficiently and courteously a public service corporation may, in the main, be serving its customers, a disgruntled busybody, assisted by a lawyer on the lookout for a fee or political preferment, will find no difficulty in securing ninety-nine signatures to a complaint, to be added to his own to make the hundred; and many of the ninety-nine signers will not feel that it is necessary even to read the complaint. By throwing this burden upon those who are dissatisfied, a great saving could be effected for the benefit of the taxpayers at large who are not directly interested and yet are obliged to pay for the large and expensive organizations of our commissions. The sums spent annually by some of these commissions, the members of which are so keen in the interest of reform as applied to others, is nothing short of a scandal.

I admit that Mr. Thompson and others agreeing with him may be warranted in claiming that some of these are not suggestions of a constructive character, for the politicians and the reform enthusiasts would not permit such simplifications of the law. Certainly the professional politicians, except under pressure from the voters, would not permit any changes in the laws which would decrease the number of salaried offices, many of them sinecures.

Then the next best suggestion that I can make is that we engineers make a serious effort to learn the facts as to commission regulation as now practiced in this country, and, having learned the facts ourselves, that we do our best to educate the public and particularly the *honest* reform enthusiasts. But it appears to be evident that we engineers as a class are not yet in a position to so educate others, for we disagree among ourselves.

May I suggest to Mr. Thompson that he read again my paper, paying particular attention to the opening paragraph. If he will do this I think he will find that I have not said nor in any way implied that the government, through the commissions or any other legally constituted agency, should keep "hands off" from the corporations.

On the questions involved in regulation by commissions, and particularly as to "rules for capitalization," I would refer Mr. Thompson and others to a paper entitled, "Public Service Commissions," written by my partner, Alten S. Miller, for the 1912 meeting of the American Gas Institute, printed in the Transactions of the institute. This paper might well be studied by all interested in the impartial administration of the law, and particularly as applied to the public utilities.

In this connection and in conclusion, in view of the loose ideas held by many on this subject, including some members of the legal profession, it may be timely to point out that the courts, including the U. S. Supreme Court, do not have the power to fix rates for service. If the legislative authority has fixed a rate which in the opinion of the court is confiscatory as failing to afford a fair return upon the present fair value of the property involved in the service, the court can make void the action of the legislature. This, of course, means that our courts do not afford us complete protection against the vagaries of our commissions, and particularly so when we bear in mind that many cases which should be appealed to the courts are not so appealed through lack of confidence in the courts, through considerations of policy, and fear of the expense.

If the responsible representatives of our public utilities would unanimously decide to coöperate in every fair way with the commissions, and then to fight to the farthest limit for their rights, I believe we would be on the way to better conditions, for not only would the public then be educated, but the commissions and the courts would receive most needful education.

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PAPERS AND DISCUSSIONS

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# THE GROINED ARCH AS A MEANS OF CONCRETE FLOOR CONSTRUCTION.*

By H. Whittemore Brown,† Junior Boston Society of Civil Engineers.

CONTENTS.



Note. This paper is published in advance of its presentation before the Society. Discussion is invited, to be received by the editor before December 10, 1916, for publication in a subsequent number of the Journal.

* Abstract of a thesis at the Massachusetts Institute of Technology, June, 1915.

† Assistant, Testing Materials Laboratories, Massachusetts Institute of Technology.

LIST OF FIGURES.*



## GENERAL CONSIDERATIONS.

IN this treatment of the subject of groined arches as a means of concrete floor construction, I shall first trace through the reasons why I believe that present methods of reinforced concrete construction are far from ideal; then show how I believe that a very marked improvement can be made by introducing a groined arch lower face to floors, thereby doing away with all steel reinforcement except a comparatively small amount running along the center lines of the columns to resist the thrust of the arches. Next, I shall treat rather briefly the method employed by me in the design of a test model, and follow this with a description of the construction and testing of this model.

* Figures 1 to 9 inclusive appear on a plate inserted at page 448.

The results of the tests as shown by this description, together with the photographs, I consider ample proof of the statements and reasoning.

Let us first consider two fundamental characteristics of concrete, — its plastic condition while being formed, and the relation between the tensile and compressive strength.

Concrete being mixed and poured on the work, as the custom now generally is, may be molded into any desired shape, the only restriction being upon the containing form and the difficulties encountered in its construction; in other words, as far as the formation of the material itself is concerned, it is readily adapted to a large variety of shapes, including curves as well as angles and straight sections. Compare this with other structural materials, wood, for instance, and we find that wood, if to be made curved, must either be steamed, so that the fibers themselves are bent to conform with the desired curve, or cut through the fibers, in which case the material is subject to a marked weakening. With steel the difficulty again becomes apparent in attempting to roll shapes anything but straight; that is, from the very nature of the manufacture, rolls cannot be easily adjusted to turn out curved members.

Concrete has another marked property which distinguishes it from many other building materials; that is, it is many times stronger in compression than it is in tension. It is the recognition of this property that has given rise to the use of steel reinforcement embedded in the concrete to assist the structure to withstand the tensile stresses.

Next let us consider how present-day reinforced concrete construction makes use of the two characteristic properties of the material above outlined. We find very little attempt being made to make use of the plastic nature of the material. Rectangular beams, etc., are common; in fact, the tendency seems to be rather to adapt concrete to existing types of construction than to develop a type of construction which makes use of the many individual characteristics of the concrete.

Let us analyze the conditions found in an ordinary reinforced beam. Referring to Fig. 1, which shows the distribution of stress over the cross-section of an end-supported beam, it may be seen that only the material above the neutral axis is under compressive stress; furthermore, this compressive stress varies in magnitude from zero at the neutral axis to the maximum allowable value at the upper surface, thus giving only one half the maximum economy in that portion of the beam which is subjected to compressive stresses. The concrete below the neutral axis carries practically no direct stress, the tensile strength of concrete usually being neglected in the design; this concrete, then, serves only to connect the steel with the concrete above the neutral axis, so that the net economy of the entire section, as far as direct stress is concerned, is less than one third, more nearly one fourth, of its maximum value. Of course the material between the steel and the compression concrete is very necessary in order to carry the shear developed in the beam; however, the shearing strength, or what is more strictly correct, the diagonal tension, is very low when compared with the compressive strength, necessitating the use of stirrups. The economy is increased by the use of a T-section, although the gain is not very considerable.

Let us again turn to our example of wooden construction and see wherein a rectangular section for a wooden beam is an economical section. In the first place, wood is stronger in tension than it is in compression, and also the strength of wood in longitudinal shear is less than one tenth the compressive strength, so that in order to design a section for a wooden beam economically it is necessary to have considerable width to the section at the neutral axis. Again, take the case of the steel I-beam. The flanges are made heavy in order to get a large amount of the material as far from the neutral axis as possible, or where the stresses are the highest. It is not necessary that the web be of very great thickness because of the fact that steel is very nearly as strong in shear as it is in tension.

We are now confronted with the question of how the economy of the concrete can be increased. We must find some form of construction in which the majority of the stresses are compressive, for, as above stated, concrete is considerably stronger in compression than it is in tension. Also, we do not wish to limit ourselves to existing types of construction, but to be free to choose new types involving curves or other shapes not too complicated for the economical construction of forms.

Arches have been used for several thousand years to span openings by means of masonry construction. Masonry construction usually admits of no tensile stresses; in the case of the arch, the stability of the structure depends upon the stability of the abutment. Then to apply the arch to floor construction in buildings it is necessary to find some form which will have its supports concentrated in four places, thus giving the same columnar form of construction as used in buildings of other types. History again provides us with numerous examples of how this problem may be solved, viz., by the use of the so-called groined arch, which is formed by the intersection at right angles of two barrel vaults, usually having the same rise and span.

Another reason why arches are economical for the use of concrete is that a greater shearing area is obtained because of the increasing thickness of the arch as we approach the abutment, thus increasing the area of the shearing section, as shown on Fig. 2. If $C$ represents the line of action of the resultant compression in the arch ring, the plane of maximum compression will be perpendicular to this line. The plane of maximum shear will be at about forty-five degrees to the plane of maximum compression, as indicated, either $ss$ or $s's'$. Failure along the plane $ss$ will be prevented by the load on the arch; that is, the portion of the arch to the left of the section will tend to slide upward on $ss$, and this tendency will be prevented, in a large measure, by the load on the floor. Failure on $s's'$ will tend to be prevented by the increased thickness of the arch ring; that is, the area of the plane $s's'$ is greater than that of $ss$, due to the curvature of the lower face. Thus it might be expected that the ultimate compressive strength of any given cross-section of an arch with a flat upper surface would be slightly, if not considerably, higher than the same area of concrete in direct compression, where the first tendency of failure is in shear, unless specially reinforced to withstand these stresses.

The use of the groined arch is by no means new and novel; the Romans used it to some extent, and medieval builders employed it frequently in their many churches. Its use in concrete, however, has been limited to the last decade or two, the first one, so far as I have been able to ascertain, having been built in Ashland, Wis., in 1895, by Mr. William Wheeler, a consulting engineer, of Boston. The arch was here used as a roof of a filter in connection with the water-supply system of the city of Ashland, and supported an earth covering about two feet in thickness. Since that time it may be said that the arch has become the usual form of construction for this type of work, but the extension of its use to other types of structures has been practically nil.

We do not have to look very far to see the reason for this limited use of the groined arch. In the first place, for satisfactory construction of groined arches it is necessary that proper abutments be furnished. In the case of reservoirs and filters, which are usually built below the ground level, this problem is easily solved, because the surrounding earth furnishes an excellent abutment.

When, however, we attempt to apply arches to construction above ground, the problem immediately becomes more difficult. Obviously, abutments in the form of heavy buttresses would be out of the question, both from the point of view of appearance and from economy of construction. We may, however, resist the resultant thrust of the arches by running steel rods from side to side, and end to end, of the building, thus counteracting the resultant thrust at the exterior of the building at its point of emergence. Steel employed this way, however, would have to be exposed throughout the greater part of its length, as illustrated in Fig. 3. As one of the great advantages of a concrete building is its fireproof quality, and as it is a well-recognized fact that exposed steel is susceptible to a marked weakening even by a small fire, this type of construction would practically be ruled out of use. If, however, the resultant thrust is not counteracted directly at its point of emergence, but by means of a direct stress together with a bending moment produced in the column, the rods may be run in the concrete throughout the building, say, about two inches from the surface of the floor, as illustrated in Fig. 4, thus counteracting the thrust without exposing the rods, but producing a bending moment which must be considered in the design of the columns.

The maximum magnitude of this moment is readily computed by statics, and in this case occurs at the resultant thrust with a magnitude of $A \times a$ or $B \times b$ inch-pounds (if the units are given as inches and pounds).

By the use of steel in counteracting the thrust of the arches we obviate one of the serious inherent difficulties met with in their construction, viz., movement of abutments. In this type of construction we have the arch and its abutment integral so that there is no opportunity for any undue stresses from movements of the abutment. Again, by the use of the thrust-resisting steel we also obviate another difficulty met with in arch construction, namely, stresses due to temperature changes in the arch ring. The arch ring and the thrust-resisting steel expanding practically at the same rate make the temperature stresses negligible.

The following extract from Turneaure and Maurer, "Reinforced Concrete Construction," pages 333, 334, gives a good explanation of the necessity of steel reinforcement in bridge arches:—

"Theoretically, the gain in economy by the use of steel in a concrete arch is not great. If the pressure line does not depart from the middle third, the steel reinforces only in compression, and in this respect is not as economical as concrete. If the line of pressure deviates farther from the center, resulting in tensile stresses in the steel, the conditions are such that those stresses must be provided for by the use of steel at very low working values. That is to say, the direct compression in the arch is so large a factor that the limiting stresses in the concrete will always result in very small unit tensile stresses in the steel when any tension exists at all.

"Practically, the value of any reinforcement is very considerable. It renders an arch a much more reliable structure, it greatly aids in preventing cracks due to any slight settlement, and by furnishing a form of construction of greater reliability makes possible the use of working stresses considerably higher than is usual in plain masonry."

Also from Taylor and Thompson, "Concrete, Plain and Reinforced," 1912 edition, page 535:

"We find the use of steel reinforcement in a concrete arch is desirable but not absolutely necessary, as it is possible to construct an arch like the Walnut Lane Bridge in Philadelphia with the concrete laid in blocks, each block forming a voussoir like the stones in a masonry arch. At the same time, under ordinary conditions, while the introduction of steel does not, with the present knowledge of concrete arch design, permit great diminution in section, it does give considerable added strength at comparatively low cost and may prevent the formation of cracks in the concrete and take tension caused by any unforeseen action of the arch, such as settlement of foundation, improper allowance of temperature, or shrinkage of the concrete while hardening."

It will be seen from the above quotations that the chief purpose of reinforcement in an ordinary bridge arch is not to take care of the principal stresses, as in the case of a beam, but to increase the reliability, allowing for stresses caused by movement of abutments or changes in temperature. It may be said, then, that in general the reliability of an arch is measured by the reliability of its abutments. By taking up the thrust of the groined arch by means of rods, as above indicated, the arch and its abutment are thereby made integral parts of the same structure, and any unreliability of the abutments is entirely obviated. It would seem, therefore, that this form of construction obviated the necessity of any "beam" reinforcement of the arch, the thrust-resisting steel being all that is required.

Next let us consider the stability of the groined arch under various loading conditions.

It is a well-known fact that, in general, arches are better adapted for carrying uniformly distributed loads than concentrated or non-uniform loads. An arch of large rise in relation to span would be unstable under a system of concentrated loads by reason of the fact that the line of pressure in the arch ring would tend to fall without the middle third. However, if we make the arch more nearly flat, that is, make the ratio of the rise to span larger, we obviate this difficulty in a great measure. In a comparatively flat arch the crown thrust, of course, is great, but the arch is very stable under all conditions of loading. This reasoning may be better understood by reference to Fig. 5, which represents a series of concentrated loads upon an arch. If we neglect the dead weight of the arch itself, the line of pressure for the load represented by *A* would be simply two straight lines from the abutments to the point of loading. Now it will be noticed that this line of pressure lies entirely within the arch ring, whereas if we had an arch of comparatively high rise, such as is represented by Fig. 6, a load at *A′* would have a line of pressure as represented, but this line would fall without the arch ring a distance represented by *d*, causing failure of the arch at the haunch. This same advantage of the comparatively flat arch is obvious for loads at *B* and *C*, Fig. 5, for the same reason. It will be seen, therefore, that by making the arches comparatively flat, we not only decrease the quantity of concrete, and thereby the dead weight of the building on the foundations, but we also make the arch more reliable from the loading point of view. However, as the thrust of a low rise arch is greater than that of a high rise arch (where the other conditions are the same), this increase in thrust requires the use of more steel to counteract it.

Next let us consider the effect of loading only alternate bays, in a building several bays wide. By reference to Fig. 7, which shows the cross-section of a building of four or five bays loaded only in alternate bays, we see that the arch in bay *A* would tend to be unstable were the thrust-resisting rods simply run from end to end of the building, because the resulting thrust from arch *B* would have to be counteracted by arch *A*, and unless it were loaded it would tend to buckle up. To get around this difficulty and make each one of the bays a unit so that the load on the bay will not affect other bays, the rods should be bent down into each one of the intermediate columns as shown in Fig. 7, thus counteracting the thrust of the bay within itself, but producing a bending moment in the intermediate columns when alternate bays are loaded. In this manner we remove one of the most serious difficulties encountered when a series of arches are subjected to non-uniform loading.

The most important consideration from the practical standpoint is always that of cost. Let us turn, therefore, from the problem of design and compare the cost of the groined arch floor with other existing types.

One of the most important items of expense in the construction of any concrete building is that of forms. Forms may cost as much as the concrete that is put into them, so that it is imperative that the forms should be simple and easy to erect and handle. In a recent example of groined arch construction in reservoir roofs, wooden forms were used, being made up in convenient sections at a woodworking mill and transported to the job at an initial cost of about twenty cents per square foot. Having them carefully built enabled them to be used seven or eight times with a minimum amount of work in removing and resetting, the total average cost per square foot of the entire roof being given by the contractors as four and one-half cents (Springfield, Mass., Water Supply, The Charles R. Gow Co., contractor). The cost of form work for floors in the Carter's Ink Company factory, a good example of beam and slab construction, was eleven cents per square foot (Aberthaw Construction Co., contractor). The cost in the Winchester Repeating Arms Company factory, a typical "mushroom" or flat slab construction, was reported as twelve and one-half cents per square foot. To be sure, some allowances ought to be made for the increase in cost due to the height of the buildings, but this should dispel any fear that the introduction of curved forms materially increases the cost of form work; the ease of erection and the doing away with large amounts of shoring more than make up for any increase in the cost of the forms themselves.

Next consider the cost of placing the steel reinforcement. In the arch type, steel is only required running from column to column in both directions and has only simple, right angle bends. The amount of steel required is about equivalent, in the case of a test floor, to that required for this size of floor in beam and slab construction. We have, then, with the use of an arch type of floor, an elimination of nearly all of the labor of placing intricate steel reinforcement.

Another distinct advantage in this form of concrete floor construction is found in the fact that when it is desired to tear down a building, the process of wrecking is a relatively simple one, in that there is very little steel used, and what steel is found in the floors is not bonded to the concrete, inasmuch as the steel is in tension and the concrete in compression, so that the two are

PLATE I.
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BROWN ON GROINED ARCH FLOOR CONSTRUCTION.

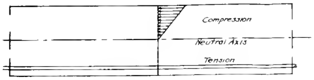

Fig 1

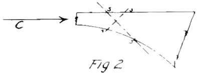

Fig 2

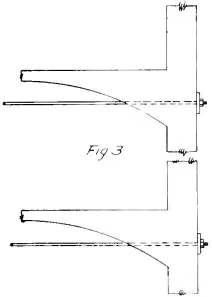
Fig 3

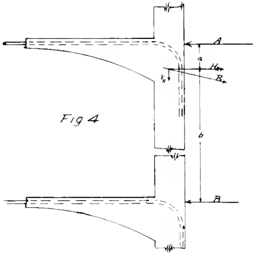

Fig 4

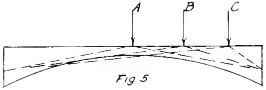

Fig 5

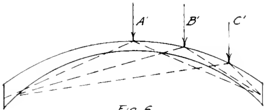

Fig 6

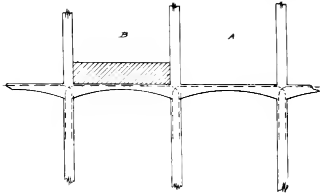

Fig 7

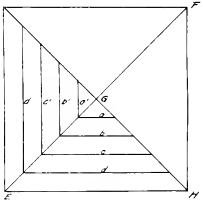

Fig 8

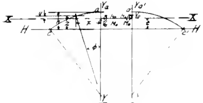

Fig. 9

readily separated. The salvage from this type of building would be, therefore, quite considerable, as the concrete could easily be crushed for use again as coarse aggregate, and a large part of the steel would also be valuable. Compare this with the present methods of wrecking concrete where the building is a total loss, as all of the material has to be thrown on the junk pile.

## Design of Test Model.

The test of any such idea as here proposed may be divided into two parts, that made by applying known methods of design to several cases of this type of structure, which may be termed a more or less theoretical test, and by the construction of an actual model and testing it to failure. Inasmuch as small models are apt to give results which materially differ from the actual conditions met with in practical construction, the writer has attempted in this test to construct a model of sufficient dimensions to warrant its being recognized as representative. A model which has a clear span of seven feet and is placed on columns four feet long ought to be considered as giving these representative conditions, yet is not without the bounds of reason when considered as an experiment. These were the dimensions adopted for the model constructed.

The subject of the design of groined arches is very sparsely treated in the text-books; in fact, the only treatment of the subject in English which the writer was able to find was the section in a book by Prof. William Cain, entitled "Steel Concrete Arches and Vaulted Structures." Briefly, his method is this: he first considers the arch as cut into a number of slices, indicated in Fig. 8 by *a*, *b*, *c* and *d*. These separate slices are then considered as ordinary arches, and their stability investigated. With the resultant thrust on the groin line *EF* of these several arches as loads, the groin line itself is then investigated for stability, and the resultant thrust at the abutment considered as the resultant thrust of the whole structure.

Another method, recommended by Mr. Horace H. Chase,* who has had experience in designing and building groined arches for reservoirs, as giving safe results, is to consider the whole

* Principal Assistant, F. A. Barbour, Consulting Engineer, Boston.

section *FGH* as an ordinary arch with a uniformly varying load and varying length of cross-section, and then apply the established methods of arch design in this case. Either of the above methods is more or less approximate, but the latter was chosen because it seemed to lend itself a little more readily to solution than that of Professor Cain.

Having decided upon a method of analysis, the next thing to determine is the proper contour to give the lower face of the arch. For a uniform load, the equilibrium polygon is a parabola, and for a load concentrated at the center it is two straight lines from the load to the supports. For a mean between the two, which is approximately the case with a groined arch, the making of the lower face in the form of a segment of a circle would seem to give the line connecting the centers of the cross-sections of the arch thus constructed (segmental lower face and straight upper face) very nearly correct. This form was adopted, and, as will be shown later, gave a line of pressure which diverged but slightly from the centers of the sections. The layout of the arch is shown by Fig. 10.

Having given the span of the arch, it is next necessary to chose the crown thickness and rise necessary to withstand the live load, taken in this case as 150 lbs. per sq. ft. For the first trial a crown thickness of two inches and a rise of twelve inches was taken.

This arch was analyzed according to a method given by Prof. C. M. Spofford in the "Theory of Structures" (Supplement, 1915).

The following equations were obtained by the method of work for the moment, thrust and shear at the crown:

$$M_0 = \frac{\int_0^{\frac{s}{2}} (m_L + m_R) \frac{ds}{EI}}{2\int_0^{\frac{s}{2}} \frac{ds}{EI}} \qquad (1)$$

$$H_0 = \frac{-\int_0^{\frac{s}{2}} (m_L + m_R) \frac{yds}{EI}}{2\int_0^{\frac{s}{2}} \frac{y^2ds}{EI} + 2\int_0^{\frac{s}{2}} \frac{ds}{EA}} \qquad (2)$$

$$V_0 = \frac{\int_0^{\frac{s}{2}} (m_L - m_R) \frac{xds}{EI}}{2\int_0^{\frac{s}{2}} x^2 \frac{ds}{EI}} \qquad (3)$$

By reference to Fig. 9 the nomenclature of the above formulæ may be more easily understood.

Let: — $XX$ and $YY$ be two axes of reference, the former being so located that $\int_0^s \frac{yds}{EI} = 0$ and the latter being an axis of symmetry.

$x$ and $y$ be the ordinates of any point on the arch axis referred to these axes.

$a$ be the length of any portion of the arch axis.

$M_0$ be the moment about an axis normal to the paper and passing through the intersection of $XX$ and $YY$.

$H_0$ $V_0$ be horizontal and vertical forces respectively assumed as acting on each half of the arch at the intersection of $XX$ and $YY$.

$m_l$ be the numerical value of the moment of the applied loads about any point $xy$ on the left half of the arch, considering this half to act as a cantilever beam fixed at the abutment.

$m_r$ be a similar moment on the right half of the arch.

$M_c$ be the actual bending moment about an axis normal to the arch axis at the point $a$.

$$M_c = M_0 - H_0 (h - t).$$

$I$ be the moment of inertia of a normal cross-section about an axis normal to the arch axis at $xy$.

$A$ be the area of a normal cross-section of the arch at the point $xy$.

$E$ be the modulus of elasticity of the material, which may be considered constant and therefore cancelled from the equations when substitutions are made.

Inasmuch as it is not the object of this paper to present any new theories of arch design, but rather to apply existing methods of ordinary arch design to the case of the groined arch as above outlined, with due allowances for safety required by the lack of knowledge of the subject, I will spend but little time here with computations, giving rather the general conclusion drawn from the test as a whole.

From the computation of the arch as above outlined, the value for the horizontal component of the crown thrust was

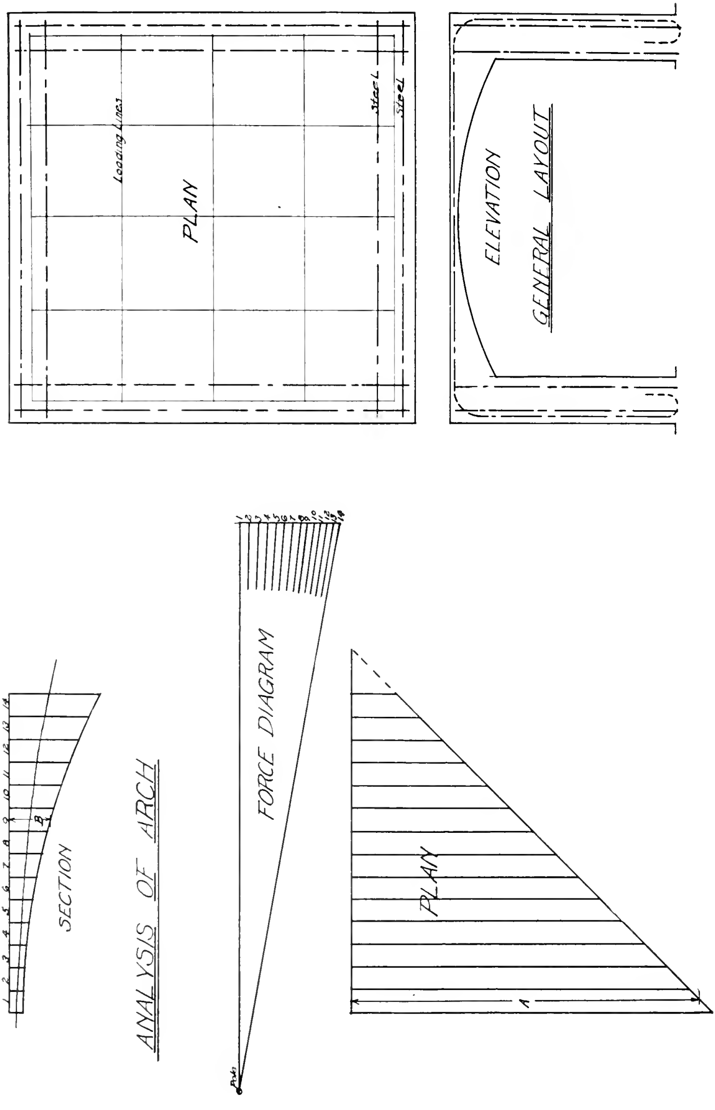


FIG. 10. GRAPHICAL WORK AND GENERAL LAYOUT OF ARCH.

found to be 4 300 lbs. It was assumed that the horizontal component of the resultant thrust was equal to the horizontal component of the crown thrust.

It was decided to use two $\frac{3}{4}$-in. plain round bars, area 0.88 sq. in. Tests for the yield point showed that it occurred at a stress of 35 000 lbs. per sq. in. With area 0.88 sq. in. and yield at 35 000 lbs. per sq. in., the total thrust at the yield point would be 30 800 lbs. Now as serious cracks did not begin to occur until a load of 750 lbs. per sq. ft. was applied, it would seem reasonable to assume that the steel reached its yield point around the 750 lb. load. I regret that the extensometer readings on the steel did not prove trustworthy enough to allow me to place more reliance on this assumption. On this basis the crown thrust of 30 800 lbs. occurring at a load of 750 lbs. per sq. ft. would mean that the thrust was 7.1 times the thrust at the designed load of 150 lbs. per sq. ft., while the load was only 5 times as great, indicating that either the steel had not yet reached its yield point, that there was a serious error in the assumptions of the design, or that the elastic abutments increased the thrust (no allowance being made for this in the original design). The determination of cause of this discrepancy is the object of a second series of tests which I have under way at the present time, although the actual test has not progressed far enough to allow any conclusions to be drawn.

## Construction of the Test Model.

In any test it is most essential for satisfactory results that the method of loading should correspond very closely with the method assumed in the theoretical design. In making tests of floors heretofore the loading has been accomplished either by using sand or cement in bags, or pig iron. Any of these methods makes it difficult to obtain room for extensometer readings on the upper surface of the floor, and the upper surface of the floor, in the case of the groined arch, is the one required for these readings on account of the difficulties encountered in attempting to make readings on the curved lower face. Also, all of these methods are likely to have some arch action in the load itself, thus departing very widely from the assumptions of the design.

In order to obviate all arch action in the load, and also to allow for extensometer readings on the upper surface, the method of loading used in this test was essentially as follows: Half pigs of iron, as usually found ready for the cupola at foundries, run a little less than twenty-four inches in length and of such width that three laid side by side will occupy slightly less than twenty-four inches. Therefore, by laying out twenty-four-inch squares over the surface of the floor, and planning for extensometer readings along the dividing lines of these squares, the iron may be piled in crisscrossed layers averaging three pigs to the layer, thus making each pile self-supporting and still leaving room for extensometer readings between the piles. (See Figs. 10 and 12.)

As the method of loading as above outlined requires a large amount of pig iron, it was thought advisable to make the test model at or near a foundry where plenty of iron was available. The Waltham Foundry Company of Waltham, Mass., had a little spare room in their yard which they were kind enough to allow me the use of for a few months, and they also had plenty of pig iron handy for use in loading the arch.

A small test pit about two feet deep was made where it had been decided to build the model. The foundation was found to be of coarse gravel, which has a fairly high bearing capacity, at least three tons per square foot. Under a load of four times the designed load, the bearing at the foot of each column was approximately this amount.

The next step was to design the forms. The main arch form was built in four sections which were bolted together along the groin lines, nailed securely at the corners, and finally strips of 2 by 3 spruce were fastened to all four sides and securely bolted at their intersections. All of this was done in order that the arch form should be self-supporting, being, in fact, an arch itself with the thrust counteracted by securely fastening the four sections together. This form rested directly on the tops of the column forms. A good idea of the forms used may be obtained from Fig. 11.

It is interesting to note in the design of the column forms the manner in which the corner joints were lapped in order that the stress on the nails in every case should be shear rather than

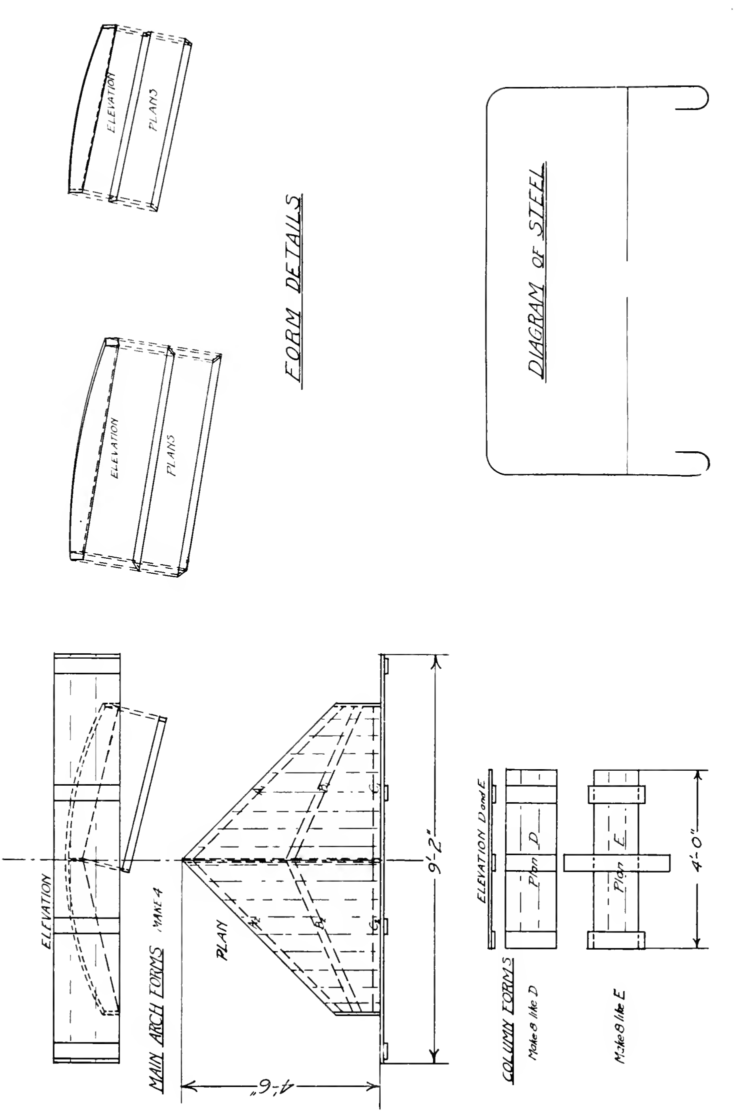


FIG. 11. WORKING DRAWINGS FOR FORMS.

straight tension. In this way any tendency towards springing the joints was avoided, and the use of clamps made unnecessary. The forms were made up in the carpenter shop of the Massachusetts Institute of Technology, and transported by truck to Waltham.

The erection of the forms required only one hour's time for the writer, with the aid of a laborer. First, two 3 by 4 spruce joists were laid across each pit for the columns, then the column forms were placed, resting on the joist by the long middle battens. After the column forms were placed and leveled, one of the sections of the arch was placed on top of the column forms and its pointed end held up in place temporarily by a light stick; the next section was similarly placed and then three bolts inserted along the intersection. This process was continued until all four sections were in place; the corners were then securely nailed, and finally, the pieces of 2 by 3 spruce were run around the outside and securely bolted at the corners.

Although some excess cost was entailed by the careful construction of the forms, it was more than made up for by the ease in erection and stripping, and also by the excellent condition of the forms after removal. With very little repairing the forms could easily be used eight or ten times, showing that although the original cost of arch forms may be slightly greater than those for flat slabs, the better construction necessitated more than pays for itself in the time saved in the erection and removal.

The labor necessary in placing the steel was of course very small. As specified in the design, $\frac{3}{4}$-in. plain round, mild steel bars were used. Tension and bending tests showed material to be about up to the standard, although not what would be termed first-class. Eight rods twenty feet long were ordered; these were bent on the job conforming approximately with the diagram in Fig. 11. Wooden blocks were wired to the bars where it was desired to take extensometer readings.

In placing the steel, care was taken to see that the rods were accurately placed, especially through the crown of the arch and the upper portion of the columns.

The concrete work involved numerous difficulties because of the lack of both time and space. Fairly representative tests, however, were made of the sand and cement with the result shown by Table 1, which shows the materials to be of good average strength.

TABLE 1.

CEMENT AND SAND TESTS.

| | | | |
|---|---|---|---|
| 24-hour Neat | | | |
| | (1) | 340 | |
| | (2) | 390 | Av. = 365 lbs. per sq. in. |
| 7-day Neat | | | |
| | (1) | 610 | |
| | (2) | 585 | Av. = 597.5 lbs. per sq. in. |
| Standard Mortar | | | |
| | (1) | 280 | |
| | (2) | 300 | Av. = 287 lbs. per sq. in. |
| | (3) | 280 | |
| Waltham Mortar | | | |
| | (1) | 270 | |
| | (2) | 295 | Av. = 262 lbs. per sq. in. |
| | (3) | 270 | = 91.5% of Standard. |
| 35-day Neat | | | |
| | (1) | 695 | |
| | (2) | 725 | Av. = 710 lbs. per sq. in. |
| Standard. | | | |
| | (1) | 290 | |
| | (2) | 295 | Av. = 295 lbs. per sq. in. |
| | (3) | 300 | |
| Waltham. | | | |
| | (1) | 290 | |
| | (2) | 280 | Av. = 285 lbs. per sq. in |
| | (3) | 285 | = 96.5% of Standard. |

Test of the cement with hydrochloric acid showed no signs of dirt or other foreign matter.

RESULTS OF SCREENING TEST OF SAND.

| | | |
|---|---|---|
| Left on | No. 10 | 18.4% |
| | No. 20 | 39.4% |
| | No. 30 | 26.0% |
| | No. 50 | 12.8% |
| Through | No. 50 | 3.0% |

This shows a well-graded sand with a minimum of fine material.

Washing the sand revealed no objectionable foreign matter.

In proportioning the mixture to be used, there was little to be considered, inasmuch as it was not the concrete that was being tested, but rather its action in the arch, so that a 1 : 2 : 4 mixture was chosen rather arbitrarily as being of common proportions. Gravel passing a $\frac{3}{4}$-in. and held on a $\frac{1}{4}$-in. screen was used. Each batch was made fairly dry, so that in placing the concrete in the arch, the joint between batches could be made nearly perpendicular to the surface of the forms, thus making the joint more efficient in carrying the stress. About an hour after the pouring had been completed, holes were made in the upper surface of the floor by pressing a steel rod into the slightly hardened concrete, thus allowing for the insertion of steel plugs for the extensometers. About twenty-four hours after the pouring, the whole floor was covered with hay and thoroughly soaked, in order that the drying out should not be too rapid. The forms were removed at the end of three weeks.

Extensometer inserts consisting of pieces of $\frac{5}{8}$-in. steel rods about an inch long were placed in the holes made in the concrete with a mixture of cement and plaster of Paris. After the concrete had been poured it was thought advisable to attempt to make strain gage readings on the concrete in the columns. Plugs were here stuck on the columns with a mixture of cement and plaster of Paris; some of these proved satisfactory and gave readings which checked up closely with the design, while others failed to adhere at all.

In order that the strain gage readings should be of some value, it was necessary to determine the modulus of elasticity of the actual concrete used in the model at the age of testing. For determining the modulus, blocks 8 by 8 by 24 ins. were made of the actual concrete used; $\frac{3}{4}$-in. rods were placed 20 ins. apart in each block, and held in place by projecting into the sides of the form. As comment on this method of placing the extensometer inserts, it may be said that difficulty was encountered because of the shrinkage of the concrete, which tended to crack the block through the plane of the rods. Since that time I have had opportunity to make other modulus tests on plain blocks, the inserts being made by boring 1-in. holes with a diamond drill, and setting the steel plugs with neat cement and plaster of Paris.

In order to measure the deflection of the arch it was necessary to design some form of apparatus which should combine the three following elements: First, it should not be elaborate or expensive, because it is likely to be ruined with the failure of the arch; second, it should be easily readable from the exterior of

FIG. 12. LOAD 450 LBS. PER SQ. FT.

the arch, so as not to endanger the observer upon a sudden failure of the arch; and third, it should be fairly accurate, at least to 0.01 in.

It was decided to make the apparatus of wood, mounting a lever with arms as 1 to 50 on a board back, having the fulcrum simply a snug fit about the supporting screw, but having the point of application on the short arm fixed by a steel point fitting into a prick-punch hole, also in steel. A general idea of the whole apparatus may be gained by reference to Fig. 12. The apparatus was made easily in a few hours by the writer in the Institute carpenter shop.

After construction, it was necessary to calibrate the apparatus. This was accomplished by placing it in a small Riehle

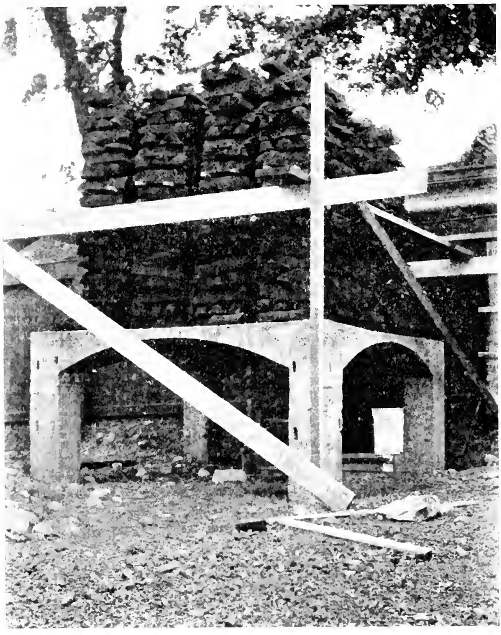

FIG. 13. LOAD 850 LBS. PER SQ. FT.

testing machine, where the deflection could be controlled easily. The actual deflection was measured with a micrometer, and compared with the scale reading on the apparatus, the scale being made with divisions fifty times the actual deflection and placed at a radius distance of fifty inches from the fulcrum. An error averaging about seven per cent. was found. The radius distance of the scale was then increased $3\frac{1}{2}$ ins., and the readings then were found to be accurate within a few thousandths of an inch. A new scale was then constructed, giving a wider range of deflection, and then tested. In this it was found that the effect of curvature became apparent in the larger deflections.

Here it occurred to the writer that the effect of curvature might be overcome by the use of a scale made of cross-section paper, and reading from a fixed point on the pointer.

From Fig. 14 it may be seen that the deflection recorded on a curved scale $B$ corresponds to the deflection of the arc $d$ rather than the actual deflection $d_1$; by the use of a scale as indicated by $C$, the deflection read along the line $c$, the path of a given

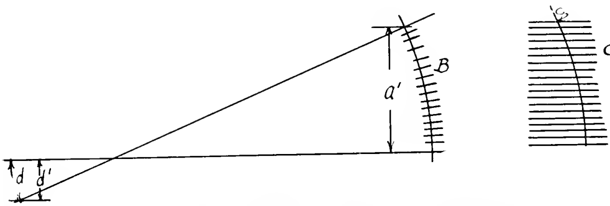


FIG. 14. ILLUSTRATING SCALE ON DEFLECTION APPARATUS.

point on the long arm of the lever, will give the vertical distance $a'$, which corresponds to the actual deflection $d'$.

## TESTING.

Tests of 6-in. by 6-in. cylinders which had been made as the mixing progressed were made at 7, 14 and 28 days; a strength of 2 070 lbs. per sq. in. being obtained in 28 days.

Modulus tests were made at 21 and 28 days, the results of which are plotted in Fig. 15. The average of the 28-day tests used in the checking of the design was 1 178 000 lbs. per sq. in.

Before commencing the loading of the test floor it was necessary to mark off the squares for the piles of pig iron, so that the loading might be carried on expeditiously without interfering with the extensometer inserts. The inserts were then

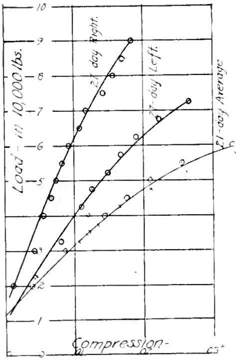


FIG. 15. MODULUS TESTS. LOAD-COMPRESSION CURVES.

punched and bored for a gage length of twenty inches, a 20-in. Berry strain gage being used.

In order that there should be a minimum amount of lifting in connection with the handling of the iron, a one-horse cart was procured, so that it was only necessary to load the iron into the cart from the pile, weigh the load, and then back the cart up to the floor, which was purposely made of convenient height for this operation. In this manner it was possible to carry on the loading quite rapidly. Loads were applied in increments of 1 600 lbs., equivalent to 25 lbs. per sq. ft., until the designed load was reached, and after that in increments of 3 200 lbs. until a load of 54 400 lbs. had been applied, equivalent to 850 lbs. per sq. ft.

Extensometer readings were taken after adding each increment of load. Dust and dirt made it difficult always to be sure that the holes for the point of the extensometer were clear, which might account for the sudden variations in some of the readings.

After a load of 150 lbs. per sq. ft. was reached, the readings on the interior of the arch had to be abandoned on account of the increasing height of the piles of iron.

Deflection readings were also taken with each increment of loading. (Fig. 16.) After a load had been applied and before another was ready, some slight settlement occurred, usually not over .003 or

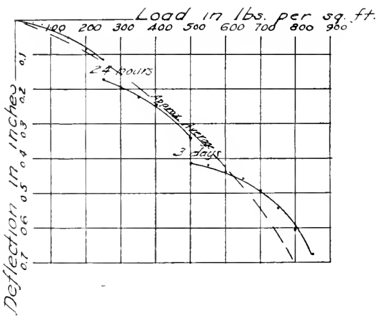


FIG. 16. DEFLECTION OF ARCH.

.004 in. Twenty-four hours elapsed before load 250 and 300, and during this time a settlement of 0.06 in. occurred. The total deflection immediately after the application of the 500 load was 0.342 in. Three days elapsed between load 500 and 550, during which time a deflection of 0.069 in. occurred, showing that the deflection becomes practically constant after twenty-four hours. The total deflection upon the application of the 850 lb. load was 0.675 in. It will be noted from the photographs that the deflection apparatus rested directly on the ground; thus the deflection readings included not only deflection of the arch but also the settlement of the whole structure on its foundations.

When a load of 750 lbs. per sq. ft. was reached, cracks were noticed on the under side of the concrete at the crown and on the outside of the columns about a foot from their tops. The next increment of loading opened these cracks and produced another set running diagonally across corners of the top of the arch about two feet from the columns. Explanation of this would seem to be that the steel had reached its yield point, thus allowing the center of the arch to fall slightly, causing cracks at the lower side at the center, on the upper side near the ends and on the outside of the columns where the tension caused by their bending was excessive.

When the steel rods were placed in the crown one set was wrapped with paper, two sets were thoroughly greased and the fourth set left untreated, but no difference in action was visible between any of them, showing that the bond between the steel and the concrete was broken without causing any undue destruction of the concrete.

The load remained on the arch for about one month without showing any signs of increase in the cracks already visible, although the deflection was not determined. At the end of that time about half of the corner piles were thrown upon the center of the arch without any appreciable change. In unloading, one half of the arch was unloaded first, leaving the other half under its full load, again without any signs of failure. Then the half of the load remaining lying nearer the edge was removed, leaving a load of approximately six tons on the middle quarter of the floor and again without any signs of failure on the part of the arch.

When it was desired to tear down the arch it was only necessary to take a sledge hammer and knock away the concrete from around the rods at the crown, cut the rods there with a hack saw, then a few blows of the sledge hammer separated the arch into four sections, which were easily removed.

## Conclusion.

I have attempted to show in the foregoing pages the reasoning pursued in the application of groined arches to concrete floor construction, and the methods used in the designing and testing of the model. I make no claim to originality in the theoretical design, my desire being chiefly to employ the easiest methods to find if there were any serious difficulties to be encountered in this new method of floor construction. The results of the test, while not of the highest scientific accuracy, owing to the limited time available for carrying on this work, were conclusive enough to show that there is great opportunity for the development of floor construction along the lines outlined in this paper.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS



# EFFECT OF CHANNEL ON STREAM FLOW.

By Nathan C. Grover,* Member Boston Society of Civil Engineers.

The engineers of the United States Geological Survey, in their work of collecting records of run-off of surface streams in all parts of the country, have established, maintained and operated gaging stations under widely varying conditions, the variations including size and regimen of streams, character of channel, facilities for transportation of men and materials, local assistants, climate, probable use of the water and degree of accuracy needed in the records. From this experience they have slowly acquired a knowledge of the fundamental requirements of systematic stream-gaging, a knowledge which has been made and is gradually being made a basis for field practice. Though many conditions may affect the cost and continuity of the records, the conditions of channel are of maximum importance in their effect on the cost and accuracy of the record. In considering such effect, distinction should be made between conditions at the gaging site and those in the channel below.

The channel and the current at the gaging site affect the accuracy of the discharge measurement and therefore the definition of the rating curve. The "control" of a gaging station,

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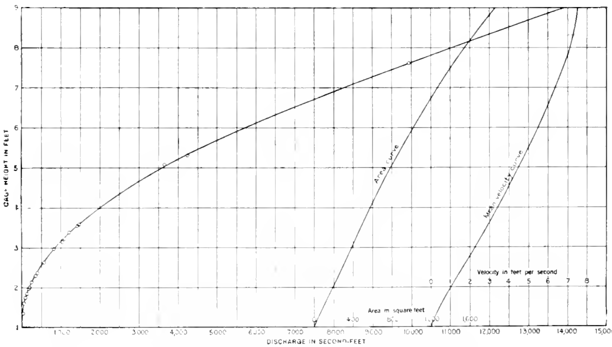
* Chief Hydraulic Engineer, U. S. Geological Survey.

or the combination of conditions of channel below the gage which fixes the shape of the rating curve (that is, the rate of change of stage with relation to the discharge or the "sensitiveness" of a station) and the changeability or permanence in the stage-discharge relation, affects the accuracy of the interpretation of a record of stage into a record of discharge and determines the number of current-meter measurements of discharge needed for such interpretation. The importance of these fundamental conditions, though perhaps long recognized vaguely, is now more definitely comprehended and appreciated. The engineer of the future, who is to select the sites for gaging stations and direct their establishment and operation, must understand the relations of channel to the methods to be adopted, to the type of station to be used, and to the accuracy and cost of the records that may be obtained.

The utility of the current meter in measuring river discharge is limited to cross-sections of streams characterized by well-distributed velocity, ranging between a minimum of about 0.5 ft. per second and a maximum of say 15 ft. per second, and absence of eddies or cross currents. The water must move in parallel filaments in order that the current meter may at all times lie in a plane perpendicular to the gaging section and may not be affected by currents moving in other directions. Cross currents and boils will cause errors in the recorded velocities, positive with some meters and negative with others. The lower limit of allowable velocity is fixed by the meter itself, which of course is not frictionless and requires an appreciable velocity of current for dependable action; the upper limit of allowable velocity is determined by the equipment used for holding the meter steadily in position in the water and by the ability of the observer to count or record revolutions of the meter.

The ratio of size and slope of channel to quantity of flowing water determines the amount of change in stage for a given change in discharge, or the "sensitiveness" of a gaging station; the greater the fluctuation in stage for a given fluctuation in discharge, the more sensitive the station. As stage is the function of discharge that is measured and recorded, either continuously or periodically, as a means of estimating daily discharge, it is necessary that the fluctuation of stage for the minimum change of discharge to be recorded shall be easily measurable on the gage used. This minimum change should, in general, be about one per cent. of the flow at any stage. If, therefore, a stream carries at low water 100 sec.-ft., a change in discharge of 1 sec.-ft. should cause a measurable change in stage. If the stream carries 1 000 sec.-ft., a measurable increase of stage for an increase in discharge of 10 sec.-ft. would be equally satisfactory. Obviously, a site for a station should be selected



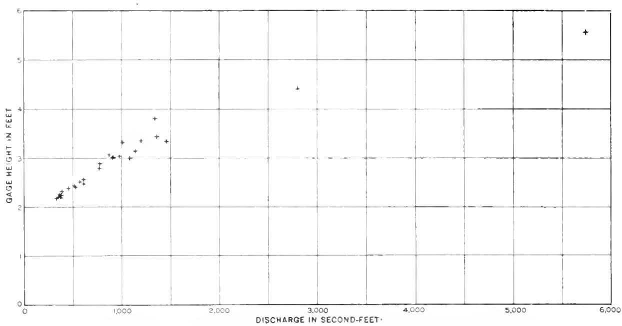

RATING CURVE FOR DEERFIELD RIVER AT CHARLEMONT MASSACHUSETTS

FIG. 1.

so as to give as large a change in stage as possible for a given change in discharge.

The choosing of a site for collecting systematic records of discharge involves much more than the finding of a sensitive cross section in which a good current-meter measurement of discharge can be made. Permanence of the stage-discharge relation and assurance that recurrences of the same stage correspond at all times to practically the same discharge are essential if dependable records of flow are to be obtained at a reasonable cost. If the stage-discharge relation is not permanent, a sufficient number of current-meter measurements of discharge must be made to serve as a basis for translating a record of daily stage into a record of daily discharge. Obviously, the number of such discharge measurements will vary from the few required to define a rating curve for a gaging station where the stage-discharge relation is permanent or where a change in that relation occurs definitely and only at considerable intervals of time, to the many, perhaps several each week, needed if the channel is constantly shifting.

The rating curve of Deerfield River at Charlemont, Mass. (Fig. 1), is well defined by a few current-meter measurements of discharge, and a good record of stage insures an acceptable




DISCHARGE MEASUREMENTS SALT RIVER AT ROOSEVELT, ARIZONA, AUGUST, 1907

FIG. 2.

record of run-off. This rating curve has not changed appreciably in four years, although current-meter measurements have been made each year, several different current meters have been used, and four engineers have made the measurements.

The measurements plotted on this rating curve show radical contrast with those made in a single year on Salt River at Roosevelt, Ariz. (Fig. 2), which illustrate the changeability of the stage-discharge relation and the futility of attempting to interpret a record of stage at this station without frequent current-meter measurements of discharge. Between the extremes illustrated by these two rivers are found all degrees of permanence of beds and banks, and each stream should be studied carefully to find the best available site for collecting records within the limit in cost imposed by the available funds.

The ideal gaging station, combining uniform and measurable velocity of current at all stages, measurable fluctuation of stage for the minimum important fluctuation, and an absolutely permanent relation of stage to discharge for all stages, can seldom be found in stretches of a river for which records are needed or so near to railroads or highways or to residents who can be employed to assist in caring for the gage and in obtaining a record of stage that its rating and operation is practicable. The ability to select a site for a gaging station to yield records of a certain degree of accuracy or to choose the best available site for collecting records in any limited stretch of stream channel is therefore of great importance. It is acquired only by experience, preferably in the same general region and with streams of the same type. Many factors that affect this relation must be carefully considered. The permanence of bed and banks *at the gaging section* may or may not be material. The rating curve of Ocmulgee River near Jackson, Ga., defined by measurements made in several years by different engineers using different current-meters, shows a permanence of relation of stage to discharge not discoverable by consideration of bed and banks at the gaging section, for the soundings made in connection with the measurements of discharge show that the bed of sand shifts greatly. The stage-discharge relation at this station is maintained by a reef or ledge extending entirely across the river a short distance below the station and at the upper end of rapids or shoals. This ledge acts as a submerged dam, and the relation of stage to discharge over it may be expressed as definitely as the formula of a standard weir, although of course complicated by a greater number of influencing factors. Because this ledge controls the stage-discharge relation, it is called the "control" of that gaging station. It is of course unusual to find a control so conspicuous as this one.

The term "control" as now used with reference to a gaging station may be defined as the ledge of rock, gravel bar, dam, stretches of banks and beds of greater or less length, combined with smoothness of bed, rate of gradient, shape of channel and various features causing backwater. Obviously the position, extent and character of the control for a site that is being considered for a gaging station cannot generally be ascertained with certainty by a single inspection, and it may be advisable to install a temporary gage and make measurements of discharge at different stages before incurring the expense of establishing a permanent station. In some sections of the country the possibility of backwater from jams of logs, ice or other drift must be considered. The danger of change in the stage-discharge relation due to the growth of aquatic plants is always present and extremely difficult to predict. When a control is affected by vegetation, the result is a gradual shift corresponding to a rising control during the season of growth, and a fairly sharp drop to normal conditions when the plants disappear in the autumn. Backwater from a tributary below a gaging station has an effect similar to that of a shifting control in a channel which otherwise may be permanent.

In recent years the Geological Survey has attempted the construction of "artificial controls" on small streams whose beds shift, as an essential part of the establishment of satisfactory gaging stations. These artificial controls are low dams, generally submerged, erected below the gaging stations in such manner as to control the flow past the stations. The effect of an artificial control on the rating of a gaging station on Logan River at Logan, Utah, with special reference to the stage-discharge relation, is shown by Fig. 3, in which the current-meter measurements of discharge made before the artificial control was constructed are numbered 1 to 12 inclusive and those made since the control was constructed are numbered 13 to 23 inclusive.

The essential features of an artificial control are (*a*) stability, (*b*) tightness, (*c*) sufficient height to serve as a control at all stages, (*d*) sufficient width (on some streams) to furnish a measuring section, (*e*) crest of such shape as to give a proper degree of sensitiveness to the station, (*f*) clear channel of approach, and (*g*) position near the gage.

Permanence of the stage-discharge relation is the principal object sought in constructing an artificial control. The structure itself must, therefore, be so built that it will be stable at all stages without serious danger of failure by undermining or washing around the end and that the crest will retain its elevation and shape under the severe conditions of abrasion pertaining to streams that carry large quantities of sand, gravel and even bowlders. The conditions for stability are those pertaining to a small dam. Abrasion of crest may be reduced to a minimum by a steel lip placed in the crest of a control. Such lip is most

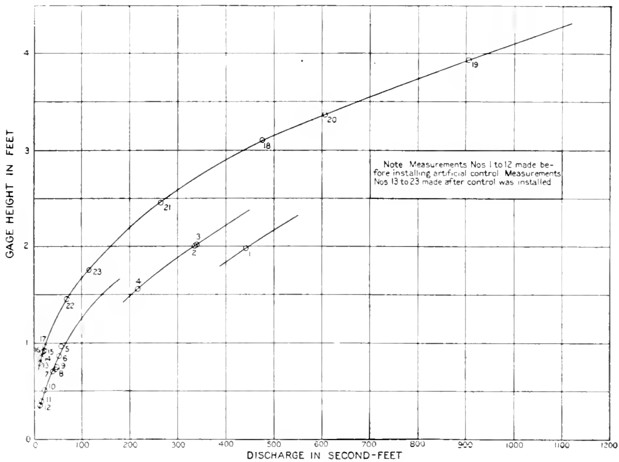



FIG. 3. RATING CURVE FOR LOGAN RIVER, AT LOGAN, UTAH.

effective if placed near the downstream edge of the crest, where it will serve both to give a free overfall at low stages and to hold a cover of sand and gravel on the upstream slope for its protection.

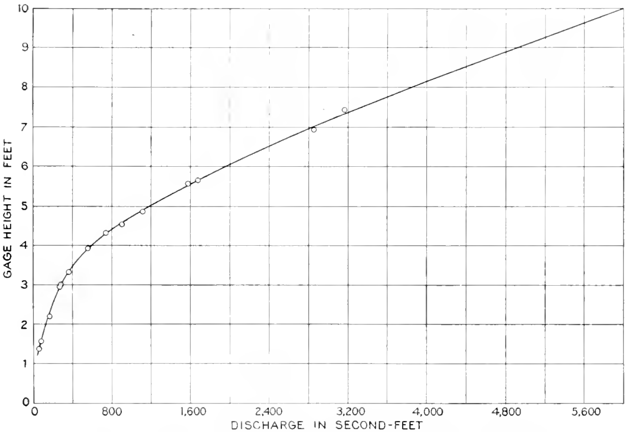
As an artificial control is constructed in order to make possible the collection of a good record of discharge by means of a record of stage, it is essential that practically all the water shall be forced to flow where it will affect the stage. If appreciable quantities of water can pass through or around a control in strata of sand, gravel, lava or other material, the control will not give satisfactory results.

The height necessary for an effective control varies with the size and slope of the stream at the control and the slope and other conditions of bed and banks below. The lower the control and the less the departure from the natural conditions of channel, the smaller will be the effect of running water in tearing down the structure and the cheaper will be its construction and maintenance. The height of an artificial control must be sufficient to prevent its drowning at medium and high stages by the backwater from a secondary and shifting natural control below. The smaller the slope of a stream and the more restricted and tortuous the channel below the control, the greater the height needed for efficiency. A stream of rapid fall below the control offers little chance for drowning of one control by backwater from a control below. The ratings for certain gaging stations shift only in the low-water sections. For such stations artificial controls of sufficient height to govern the stage-discharge relation throughout the range of shift will evidently accomplish the purpose as well as higher controls.

On many rough mountain streams it is difficult to find gaging sections at which reasonably accurate measurements of discharge, especially at low water, can be made. A section that is cleaned and made reasonably smooth may fill with bowlders during the next high water. On such streams it may be advisable to construct artificial controls with such width of crests, 12 inches or more, as to afford measuring sections.

The profile of the crest of an artificial control across the stream will determine the sensitiveness of the gaging station and therefore the accuracy of the record that can be collected. The greater the fluctuation in stage for a given change in discharge, the less the refinement needed in the record of stage to obtain the desired accuracy in record of discharge. A long, level spillway will create a pool which will fluctuate slowly and in which the stage must be recorded with great accuracy if reasonably accurate estimates of flow are to be made. The crest of an artificial control should therefore rise by steps or slopes from the lowest part, which may be in the center of the channel or near either bank, to the banks at a rate commensurate with the size of the stream and the accuracy of record desired.

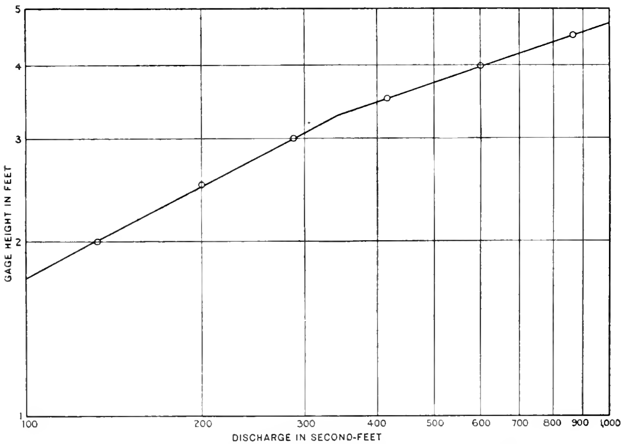
The channel of approach should be free from bowlders, débris or vegetation, in order that the artificial control may effectively maintain a permanent relation of stage to discharge at the gage. The control should be placed as near the gage as is practicable and at only sufficient distance from it to insurp that the gage shall at all stages be in still water above the share surface slope immediately above the control.




RATING CURVE FOR INDIAN CREEK NEAR CRESCENT MILLS, CALIFORNIA

FIG. 4.

The rating curve for a standard rectangular weir for which the formula for the discharge, $Q = Clh^n$, is parabolic, and will plot as a straight line on logarithmic cross-section paper. Similarly, a rating curve for a current-meter gaging station that is parabolic in form will appear as a straight line when *plotted* on logarithmic cross-section paper from the datum of zero flow. It has been proposed to use such cross-section paper for plotting rating curves that must be extended considerably beyond the stage for which current-meter measurements of discharges have been made. This method appears to be reasonably safe if the aspect of the cross section of the river at the control section or sections does not change within the limits of range in stage. There is danger, however, that with a decided change in aspect of cross section, the equation of the rating curve may change, and the rating curve which appears to be a simple parabola (Fig. 4) when plotted to natural scales becomes a broken line (Fig. 5) when plotted on logarithmic cross-section paper indi-




RATING CURVE FOR INDIAN CREEK AT CRESCENT MILLS, CALIFORNIA.
LOGARITHMIC SCALES

Fig. 5.

cating a combination of parabolas. A straight-line extension of the low-water curve would then lead to gross error for high stages.

A transfer of control from one cross-section to another or from one section of river to another with changing stage may lead to similar changes in shape of the rating curve, changes that may or may not be apparent to the eye when plotted to natural scales. Frequently such transfer of control and the combination of rating curves resulting from the different controls lead to reversals in the rating curve that were for a long time enigmas to those engaged in stream gaging. The rating curve of Kickapoo River at Gay's Mills, Wis. (Fig. 6), shows a sharp reversal which was well defined by many measurements made in a series of years and with the greatest care. The peculiar shape of the curve led engineers to think that it must be in error and hence much care was used in all of the work. The rating curve of East Fork White River at Shoals, Ind., shows the same kind of a reversal, although somewhat less marked, and many similar instances could be cited.

If two standard weirs be placed in the same stream, the

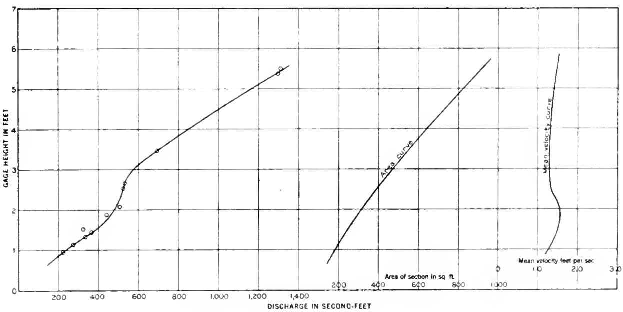



Fig. 6.

upper one 3 ft. long and the lower one 2 ft. long and 6 ins. lower than the first one, the rating curve for a gage placed in the pool above the upper weir must have a reversal at the stage where the lower weir drowns out the upper weir. Below a gage height of about 2 ft. the upper weir forms the control for the section of the gage; above that stage the lower weir forms the control.

No doubt many gaging stations are now operated at which the transfer of the control from one section to another with change in stage is disclosed by examination of the site or by study of the rating curve. Such transfers in control may explain the cause of a change that appears in one part of a station rating curve while other parts of the curve are permanent.

The selection of a site for a satisfactory gaging station involves, therefore, a careful study of the river channel not only in the immediate vicinity of the site proposed but also for a distance below, varying from a few hundred feet to several miles. This examination must be sufficiently thorough to disclose the facts as to the gaging section, the sensitiveness of the site, especially at low stages, and the shape and permanence of the control. Under some conditions of channel, the controlling factors may be so obvious that an inspection of the site at a low stage of the river would disclose, with reasonable certainty, the characteristics of a gaging station established there; under other conditions several inspections at different stages of the river may be needed; and under still others it may be necessary to install a gage and try out a site for several weeks or months by recording daily stage and making several current-meter measurements of discharge at different stages before safe decision can be reached as to the character of record that may be obtained.

On the character of channel depends largely the cost and accuracy of a record obtained at any site. The gaging section will determine largely the accuracy of current-meter measurements and therefore the accuracy of the rating curve. The shape of the control will determine the sensitiveness of the station and therefore the accuracy with which a record of stage may be translated into a record of discharge. The permanence of the control will determine the permanence of the stage-discharge relation and therefore the dependability of the rating curve and the number of current meter measurements required as a foundation for the rating curve or succession of rating curves needed for interpreting the record of stage.

## MEMOIRS OF DECEASED MEMBERS.

### EDMUND K. TURNER.*

EDMUND K. TURNER, for many years a leading member of the engineering profession, died at the Corey Hill Hospital, Brookline, after a short illness, on May 6, 1915.

Mr. Turner was born in Marblehead, Mass., May 11, 1848. His father, Joseph P. Turner, was for many years cashier of the National Grand Bank of that town. His mother, who died when he was a child, was Mary K. Kimball, of Marblehead.

In September, 1867, he entered the Massachusetts Institute of Technology, which had only just been started, and from which the first class had not yet been graduated. He chose the course in civil engineering, from which he graduated in 1870. He showed great ability and diligence in his work at the school, and by his high scholarship and his manly character he won the esteem of his teachers and classmates. He early took an interest in military work and was all his life an earnest believer in the efficacy of strict discipline. Military drill was at that time, as at present, one of the requisites in the course of study at the Institute, and Mr. Turner became one of the captains of the Institute battalion.

After leaving the Institute he was at once engaged as engineer of construction of the Nashua, Acton & Boston Railroad, a short line now a part of the Boston & Maine system. On the completion of this work, he was appointed chief engineer of the Fitchburg Railroad, a position which he held for about eighteen years. During a portion of this time he was also assistant superintendent of the Vermont and Massachusetts Division of the Fitchburg Railroad, thus gaining an experience in railroad operation as well as in railroad construction and maintenance.

About 1890 he resigned his position as chief engineer of the

* Memoir prepared by George F. Swain.

Fitchburg Railroad and entered upon private practice as a consulting engineer in Boston, in which he continued up to the time of his death.

In 1895 he became consulting engineer for the Massachusetts Board of Railroad Commissioners, on various problems in connection with the construction of the Boston Elevated Railway, the appraisal of railroad and street railway properties, and other matters. He continued to serve the Commission in matters of this kind up to within a short time previous to his death.

In the course of his practice as consulting engineer, Mr. Turner served on many important commissions appointed by the courts, as provided by statute, for the purpose of deciding on plans for the abolition of grade crossings throughout the state of Massachusetts. Probably no engineer in New England has had as large experience in work of this kind as he had. He was also consulting engineer for the Fitchburg Railroad Company and made annual inspections of that property and advised its officers with reference to maintenance and needed improvements.

Mr. Turner joined the American Society of Civil Engineers in 1891 and was a Director of the Society from 1899 to 1901. He was also a member of the Institute of Consulting Engineers and of the Boston Society of Civil Engineers, which latter society he joined in 1874.

Mr. Turner was one of the best-informed engineers in the country on transportation matters, and he brought to the consideration of those subjects not only a wide knowledge and extensive experience, but a well-balanced judgment, which led him to see at once to the root of the matter and to disentangle the main question from all relatively unimportant details. His knowledge covered not only American practice, but European practice as well, and during nearly a quarter of a century he made annual trips abroad for study, observation and recreation. He was also well read in a wide range of subjects, and a lover of art and music, and especially of all that is beautiful in nature.

The soundness of Mr. Turner's judgment is shown by the esteem in which he was held by members of the legal profession with whom he had occasion to work in connection with the various grade-crossing commissions upon which he served, the other members of which were generally lawyers. One of his friends in the legal profession writes as follows regarding less known services not in the engineering line:

"Entirely apart from Mr. Turner's services in the strict lines of his profession, he was much sought after by his friends and others for advice on legal and business matters and on affairs of property interests. His selection as executor of the William C. Todd estate, involving a very considerable sum of money given for educational purposes and as to which there were several legal controversies, is an illustration of how he was regarded by one of the early business men of New England. Those who had occasion to consult him always obtained a sympathetic hearing and definite advice that was always honest and sound, though perhaps not always in accordance with their desires."

Mr. Turner was of reserved demeanor, undemonstrative and somewhat difficult to become acquainted with, but he was much beloved by those who really knew him, and respected by all with whom he came in contact, including his employees when chief engineer of the railroad company. He was a strict disciplinarian, not only with others, but with himself, but absolutely just in all his judgments. There was nothing indefinite about Mr. Turner. If you asked him a question, you always obtained a definite answer and found out exactly what he thought, even if it did not agree with your ideas or desires. These qualities made him an excellent witness, and in the course of his professional experience he had many occasions to appear before courts or other legal tribunals.

Mr. Turner's death will be a great loss to the engineering profession. There are not many men in any profession with his sturdiness and independence of character, his modesty and his attainments. Those who knew him well will, in addition, feel a sense of personal loss in his passing and will long remember his many admirable qualities.

## EMORY ALEXANDER ELLSWORTH.*

DIED DECEMBER 8, 1915.

EMORY ALEXANDER ELLSWORTH, the son of John F. and Maria (Lawrence) Ellsworth, was born at Hardwick, Mass., August 3, 1853. He was educated in the public schools of his native town and graduated from the Massachusetts Agricultural College in the class of 1870, which was the first graduating class to leave this institution.

After his graduation, Mr. Ellsworth was employed by E. E. Davis, civil engineer, of Northampton, Mass. One of the big jobs he had charge of while assistant to Mr. Davis was the installation of a new municipal water supply for the city of Holyoke, which was completed in 1874. Shortly afterwards Mr. Ellsworth formed a partnership with F. E. Davis, nephew of his former employer, the firm opening an office in the city of Holyoke under the name of Davis & Ellsworth.

In 1879 Mr. Ellsworth left the firm of Davis & Ellsworth to become principal assistant and head draftsman for D. H. & A. B. Tower, of Holyoke, who were the largest firm of paper mill architects in the country at that time, and who designed no less than twenty paper mills in the city of Holyoke alone.

In 1883 Mr. Ellsworth resigned his position with D. H. & A. B. Tower and went into private practice for himself as engineer and architect, opening an office in Holyoke, which he retained uninterruptedly until his death. In 1899 he took into partnership John J. Kirkpatrick, and in 1907, when Mr. Kirkpatrick left the firm to be superintendent of the Holyoke Water Works, Lyman J. Howes became a member of the firm of Ellsworth & Howes and was so connected at the time of Mr. Ellsworth's death.

Besides attending to his private practice, Mr. Ellsworth was city engineer of Holyoke for the years 1884, 1885, 1887, 1888 and 1889. Among the larger works done by him in this capacity were the Whiting Street and Bray municipal reservoirs.

From the very start after opening his office in 1883 until his death, Mr. Ellsworth had a large practice, both as engineer

* Memoir prepared by James L. Tighe and A. H. Lavalle.

and architect, throughout New England, New York and Canada. His practice covered the design and construction of numerous paper mills and other industrial establishments, public buildings, apartment houses and private residences, installation of water supplies and water powers, dams and sewerage systems, etc.

Mr. Ellsworth was twice married. His first wife was Lucy J. Bradford, of Northampton, Mass., and his second, Carrie Meach, of Holyoke. With his first wife he had two sons and a daughter, all of whom, together with his second wife, survive him.

Mr. Ellsworth was a man of very gentle, retiring and modest manner, high integrity, thoroughly honest in everything, and kind-hearted in the extreme. He had a most equitable temperament, and, as a proof of this, it is only necessary to state that of the numerous assistants whom he employed and who were under his charge during his forty-five years of practice, not one of them ever knew him to lose his temper or show any irritation, even under the most trying circumstances. He was always most considerate, in fact, indulgent, towards his help, who all remember his genial personality and kindness of spirit.

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## SAMUEL FOSTER JAQUES.*

Samuel Foster Jaques was born in Newburyport, Mass., on November 29, 1865. He was the son of Edmund and Rachel (Foster) Jaques, both descendants of the country's early settlers. His accidental death occurred in Binghamton, N. Y., on January 8, 1916, as the result of a fractured skull which he sustained by being thrown headlong from his motorcycle to a brick pavement when the machine skidded on a street car-track. He never regained consciousness after his fall and expired in a hospital three hours later.

Mr. Jaques was educated in the public schools of Newburyport and then started to learn the engraver's trade. In 1886 he entered the Massachusetts Institute of Technology, where he remained two years. From 1887 to 1891 he was with Wm. H.

* Memoir prepared by William Nelson, Harrison P. Eddy and F. Herbert Snow.

Whitney, of Boston, Mass., and from there went South to Tennessee and Georgia on engineering work. During 1892 he was engaged on preliminary sewer work in Brockton, Mass., and after a short engagement with Aspinwall & Lincoln, of Boston, in 1893, he returned to Brockton.

In 1894 Mr. Jaques entered the engineering service of the United States Government at Portland Head, Me., and went from there to Dover, N. H. During 1895 he was in the employ of F. Herbert Snow, then city engineer of Brockton, Mass. In 1896 Mr. Jaques was with George A. Kimball on sewer construction in Arlington, Mass., and with Percy M. Blake in 1897-98, at Hyde Park, Mass.

From 1898 to 1903 Mr. Jaques was in the city engineer's office at Worcester, Mass., and from there went to Dover, N. H., where he was engaged in private engineering practice until 1905.

He went to Lestershire, N. Y., to construct a sewer system for Morrison & Farrington, of Syracuse, N. Y., and entered the employ of the city of Binghamton, N. Y., as assistant city engineer in 1905, which position he held until his untimely death.

Mr. Jaques joined the Boston Society of Civil Engineers in 1903. He was a member of the Binghamton Engineering Society; Binghamton Lodge No. 77, F. & A. M.; Binghamton Chapter No. 139, R. A. M., and Malta Commandery No. 21, Knights Templar. In his religious life he was a Congregationalist, and was a very active and faithful worker in the church.

He was a man of quiet tastes, and was very devoted to his family and profession. Uniformly kind, courteous and considerate of others, he enjoyed a wide circle of friends.

Mr. Jaques married Abbie P. Noyes, of Newburyport, Mass., on September 12, 1893. He is survived by his wife, one daughter, Mildred Noyes Jaques, both of Binghamton, and one brother and one sister of Newburyport, Mass. The funeral services were held in the Old South Chapel, and interment was made in Oak Hill Cemetery, Newburyport.

## CHARLES W. ROSS.*

Charles Wilson Ross was born in West Boylston, Mass., March 8, 1849, and was educated in the public schools of that town and at Worcester.

His father, William J. Ross, was a builder, but passed many years of his life on a farm in West Boylston. He was an inventor of some note. Among his inventions was a winnowing and threshing machine and a sulky plow. The son inherited an inventive genius, which was turned to good account during his active life, although practically no effort was made to reap a financial reward from it, as whatever improvements he made were given freely to the public.

He remained at home during his boyhood days, working with his father as a builder and willingly performing the manifold duties devolving upon him during his farm life. Accustomed to long days and hard work, Mr. Ross left the farm in 1869 endowed with all of those sturdy qualities of the pioneers "who brought forth on this continent a new nation."

With firm muscles, inventive genius, good nature and a willingness to work, he found no difficulty in quickly securing a good position where such qualifications were in demand.

His first employment was in the Newton Cemetery, where he soon was promoted to the position of assistant superintendent. He remained there for twenty-one years, when he resigned to accept a position of public trust, being appointed superintendent of streets of Newton, Mass., December 8, 1890. When the revised city charter of 1897 became effective in 1898, he was appointed street commissioner and took under his charge all work relative to the public ways, bridges, parks, playgrounds, burial grounds, street lighting, sewers and drains, and continued to hold that position until April 15, 1914. During the years 1905 to 1908 he also had charge of the gypsy and brown-tail moth suppression work.

His administration, covering a period of twenty-four years, was honest, progressive, efficient and economical. Never a suspicion existed that he failed in any way to conduct the different departments under his charge for the best interests of the city, without fear or favor.

* Memoir prepared by Wm. E. McClintock, Edwin H. Rogers and George E. Stuart.

Shortly after his appointment he discarded the old and costly methods of building streets and adopted the plan of using a thin coating of screened broken stone spread over the old gravel roads and finishing with a steam roller to give a hard, smooth surface. He was the first street superintendent in the country to make this radical departure. In a few years, under Mr. Ross's direction, the streets of Newton attained the reputation of being the best of any city in the country, and they maintained that reputation throughout his administration. When Mr. Ross began to note the destructiveness of automobiles he tackled the problem with the same spirit as he did the broken stone roads years before, and solved it in an equally satisfactory manner.

In July, 1898, Mr. Ross was appointed a member of the Massachusetts Highway Commission by Governor Crane, which position he held for two years until compelled to give it up because of the increased demand upon his time by the city of Newton, where he was serving as street commissioner at the same time. With a ripe experience acquired by many years on similar work he was an invaluable member of the Highway Commission, and much of the credit for the splendid system of Massachusetts state roads is due to his observations and timely suggestions.

His never-failing good nature made friends for him wherever he went. His advice on methods of caring for the common roads was of inestimable value to the road masters of cities and towns in all parts of the state. He was loyal to the Commonwealth and at all times insistent that she was entitled to the best at the least possible cost. With his warm heart and sunny smile Mr. Ross was beloved by his colleagues and every employee both in the field and office.

Mr. Ross and Mr. Richard A. Jones, of Waltham, took the initiative steps to organize the Massachusetts Highway Association. At one time he was president. He always took a deep interest in its affairs, attended all the meetings, and was ever ready to read an experience paper and discuss methods of building. He was known to road builders in all parts of the country, as he took the time to attend many of the state and national conventions.

Mr. Ross was a member of the First Baptist Church of Newton Centre. While he talked but little upon religious subjects, he was loyal to his church, and those most intimate with him never heard a word or witnessed an act which intimated that he did not accept the teachings of the Great Master and apply them in a practical manner.

Those who were admitted within the inner circle were charmed with the natural simplicity of his home life, where mutual love and warm-hearted consideration reigned supreme. Three and a half years ago Mrs. Ross was stricken with severe illness which rendered her entirely helpless. During all those years the fond husband has cheerfully responded to every call for care and sympathy, ever hopeful that a change for the better might come.

In 1914, wearying of the increasingly exacting duties as street commissioner, after twenty-four years' service Mr. Ross resigned the office and accepted the position as superintendent of the Newton Cemetery, which he held at the time of his death, April 12, 1916.

The fact that he passed the forty-seven years of his active life, after leaving home, in the service of either the Newton Cemetery or the City of Newton speaks louder than words of his ability and of his even disposition.

Mr. Ross married Miss Ella R. Gould, and is survived by her and five children: Mr. H. Wilson Ross, of Worcester; Mr. George W. Ross, of Boonton, N. J.; Mrs. Edward E. Lothrop, of Worcester; Mrs. Arthur Hodges, of Newton Centre, and Mrs. Edward E. Savory, of Auburndale; also by two brothers and a sister, Leonard W. Ross, superintendent of Boston Cemeteries; Walter D. Ross, president Ross Bros. Co., Worcester, and Mrs. Handy, Montclair, N. J.

Mr. Ross was a Mason, being a member of Dalhousie Lodge, A. F. & A. M., and Newton Chapter, Royal Arch Masons, of Newtonville, and held membership in the Massachusetts Highway Association, Massachusetts Horticultural Association, American Park Association, National and New England Associations of Cemetery Superintendents, Boston Society of Civil Engineers, and was an Associate of the American Society of Civil Engineers.

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PAPERS AND DISCUSSIONS

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# THE PORTLAND BRIDGE.

By Eugene E. Pettee, Member Boston Society of Civil Engineers.

(Presented September 20, 1916.)

## History.

The first bridge at the site of the structure described in this paper was a toll bridge built by a company about 1828. It was a pile bridge, 25 ft. wide and about 4 ft. above high water, extending from what was then Cape Elizabeth to within about 200 ft. of Commercial Street, and had a leaf draw at about the location of the present draw. From this last point it ascended on a grade of about 9.2 per cent. to a point about 50 ft. beyond Commercial Street, and from that point to York Street the grade was 12 per cent. The old Portland, Saco & Portsmouth Railroad, now the eastern division of the Boston & Maine Railroad, passed under the bridge about 10 ft. south of Commercial Street.

The Bridge Company was bought out by the town of Cape Elizabeth, and the right of way was transferred to the county of Cumberland. Under a petition from the citizens of Cape Elizabeth and the city of Portland, the grade of the bridge was dropped to the level of Commercial Street, and the upper part abandoned. In subsequent years, the railroad companies es-

Note. Discussion of this paper is invited, to be received by the editor before February 10, 1917, for publication in a subsequent number of the Journal.

tablished a freight terminal east of the bridge site, and put in, without authority from anybody, twenty-four additional tracks (Fig. 2), and created what subsequently became known as the "Gridiron of Death," and were indicted as a nuisance. To stave off the results of the indictment, by an agreement under the preamble of motive "to establish safety of travel," the Railroad Company built the Clark Street Bridge (Fig. 1) and laid out a line of additional travel by the head of their wharf into State Street, to be crossed by only one track, serving in-

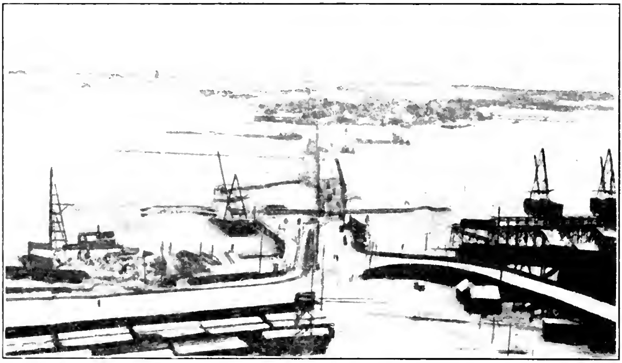

Fig. 1. Old Bridge and Temporary Structure.

termittently the Steamboat Wharf. In 1908 it built the coal elevators on the east side of the old bridge right-of-way (Fig. 2), and the Railroad Commission gave it the right to lay a track to them, which, in operating, resulted in about one hundred and fifty crossings in ten hours over the agreed-upon safety line of travel.*

The original bridge had been repaired and rebuilt from time to time, and when work began on the new structure the old bridge (Plate II) consisted of a pile trestle with floor at elevation 17.00 above mean low water, and a steel truss swing draw, with

*This data furnished by E. C. Jordan, M. Am. Soc. C. E., Portland, Me.

two 70-ft. openings. The roadway of the bridge varied in width from 26 ft. to 32 ft., and there was but one sidewalk. The tracks of the Street Railway Company were carried on its own trestle directly east of the bridge, except at the draw, where the track swung in on to the roadway. As the draw had a roadway only 20 ft. wide, and as all traffic had to pass through this narrow throat, traffic frequently became congested. This congestion was very bad when the draw had to be opened, and caused much delay and annoyance. The bridge was in

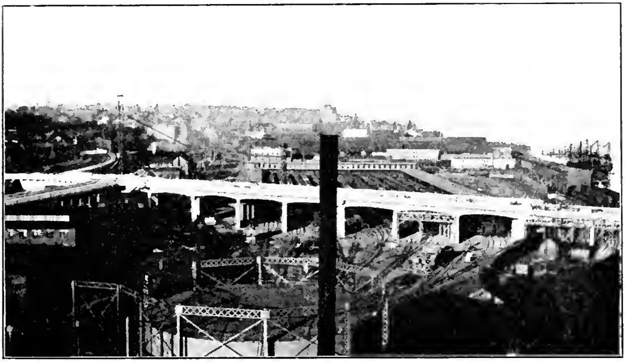

FIG. 2. SECTIONS 4, 5 AND 6.

constant need of repair, particularly the draw, which was badly corroded beneath the floor. Many people were timid about using the bridge, and there was a strong demand for a new one, which finally resulted, in 1913, in the passage by the legislature of a bill authorizing the Cumberland County Commissioners to build a new bridge, provided the Portland Terminal Company, the successors of the Portland, Saco & Portsmouth Railroad, would agree to pay 40 per cent. and the Portland Railroad Company (operating the street railway) would pay 10 per cent. and that the bridge should not cost more than one million dollars. This consent of the corporation was obtained, and the County Commissioners appointed J. R. Worcester & Co., engineers, to make plans and take charge of erection of the bridge. A survey of the site was begun on March 1, 1914, and contracts were signed November 16, 1914. The new bridge was opened to traffic July 20, 1916 (Fig. 9).

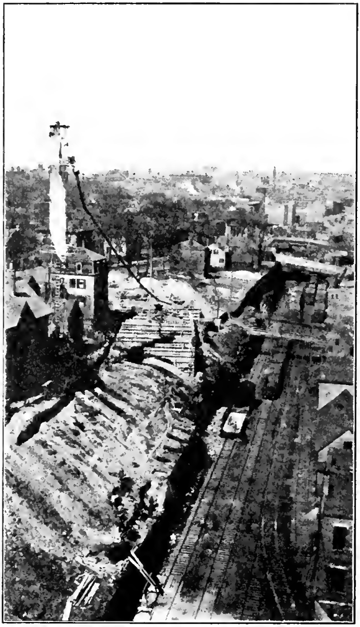

FIG. 3. CONSTRUCTING SECTION 6, TYNG STREET TOWER AT LEFT.

## GENERAL DESCRIPTION.

The roadway of the new bridge starts at the street level in South Portland and runs on a slight grade to the high level of the streets just beyond the water front in Portland. This gives a rise of about 40 ft. and a length of about 3 000 ft., providing ample clearance over the railroad tracks on the Portland waterfront and 30 ft. of headroom under the draw at high water (Plate I). A large part of the city of Portland is built on high ground, and most of the traffic comes to the bridge at this high level. By bringing the bridge to this level, heavy grades were avoided and a more direct route provided.

In plan, the lines of the bridge coincide with the street lines in South Portland, from which point the new lines diverge from the old by a small angle, so that in a distance of about 700 ft.

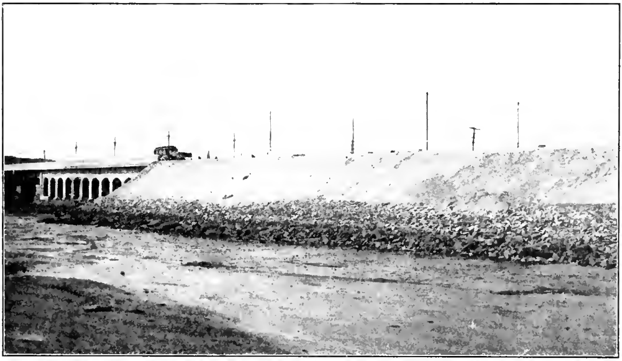

FIG. 4. SECTIONS 1 AND 2.

the easterly line of the new bridge coincides with the westerly line of the old bridge. From this point the new bridge continues parallel to the old bridge and runs straight across the harbor, the many tracks of the Portland Terminal Company, and Commercial Street, to the foot of Brackett Street at the edge of the upper level of the city. From Brackett Street the main approach swings to the east over a steep bank to the junction of State and York streets (Fig. 3). The street railway and most of the heavy teaming comes along York Street, while most of the automobile and foot traffic comes down State Street.

Besides the main approach at State Street, there is an entrance at Brackett Street by a rather steep grade (10.7 per

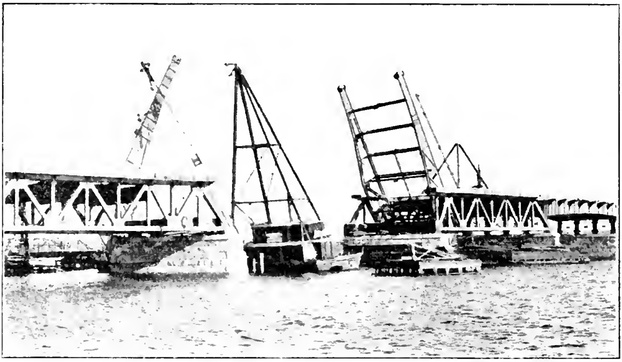

Fig. 5. Erecting Draw Span.

cent.). There is also a third approach from the west at the junction of York and Clark streets. The total length of the bridge, including approaches, is 4 000 ft.

## Details of Construction.

The bridge is divided into six sections of different types of construction.

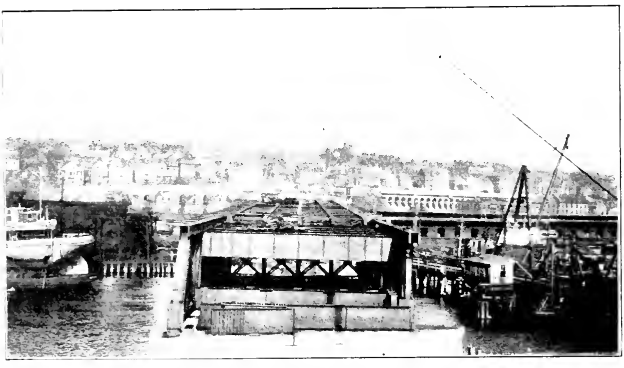

Fig. 6. Looking North on Section 3.

*Section 1.*

Section 1 begins at A Street in South Portland, and is 860 ft. long. It consists of about 60 000 cu. yds. of sand and clay fill with grassed slopes and protected by riprap to elevation 14.0, datum being mean low water. (Fig. 4).

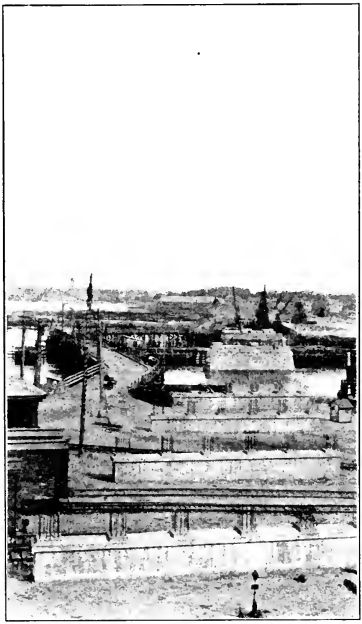

FIG. 7. VIEW FROM BRACKETT STEEET SHOWING PIERS AND TEMPORARY BRIDGE.

*Section 2.*

Section 2 is 306 ft. long and consists of 12 spans of 25 ft. each, of reinforced concrete beam construction, having the appearance of segmental arches. It is carried on pile foundations protected by filling and riprap, the ground below consisting of mud flats covered by tide at high water. (Fig. 4 and Plate III.)

*Section 3.*

Section 3 is 1 008 ft. long and consists of nine spans of 98 ft. each and a draw span having a clear opening of 100 ft. Seven of these spans have steel girders of cantilever construction with a 3-ft. rise of the bottom flange, giving the appearance of flat arches. The two spans adjoining the draw are steel trusses with horizontal chords. These two spans, with the draw span, have a level roadway. The draw span is a double-leaf Scherzer Rolling Lift Bridge. (Figs. 5 and 6, and Plates I and V.)

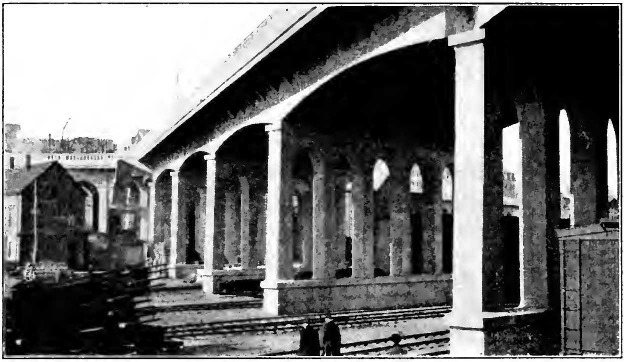

FIG. 8. SECTION 4.

*Section 4.*

Section 4 consists of 13 spans of lengths varying from 30 ft. to 67 ft., of reinforced concrete cantilever-beam construction, the bottom of the beams being crowned to give an appearance similar to the steel spans of Section 3. (Figs. 7, 8, 9, Plates VI and VII.) Section 4 has a total length of 758 ft. Sections 1, 2, 3 and 4 comprise the straight portion of the bridge and have a total length of 2 932 ft. (Plate I.)

*Section 5.*

Section 5 is known as the Clark Street Viaduct, and has 14 spans of 16.47 ft. each, and ends in a solid fill held by reinforced

FIG. 9. SECTION 4.

concrete retaining walls. The total length of this section is 333 ft. (Fig. 10.) The floor of this section consists of flat slabs carried by cross floor beams, which are supported by three lines of columns. The columns are placed under the curbs and under the center line of the roadway, and are braced longitudinally with beams having semicircular soffits, as have also the

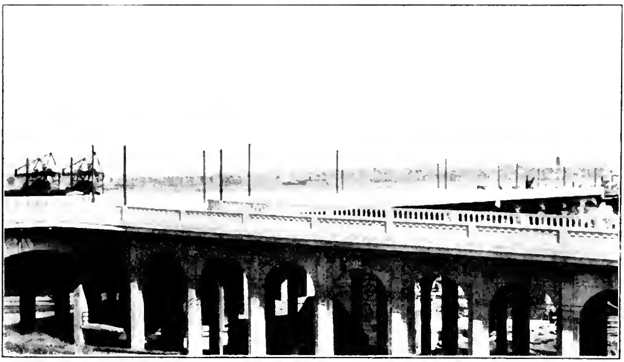

FIG. 10. SECTION 5. SECTION 4 IN BACKGROUND.

floor beams. The sidewalks are carried on curved brackets cantilevered from the floor beams. The tops of the columns, being connected together with semicircular arches in both directions, give a very pleasing effect from below. (Fig. 11, and Plate IX.)

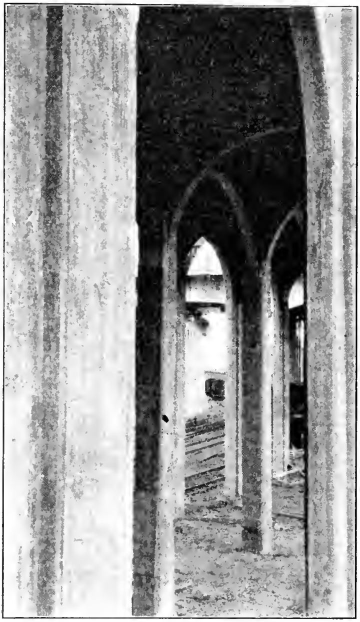

FIG. 11. SOFFITS OF SECTION 5.

*Section 6.*

Section 6 is known as the State Street Viaduct, and has forty spans of 12.5 ft. each and ends in a solid fill held by concrete retaining walls. It has a total length of 735 ft. This section is built on a steep hillside above a railroad cut. The roadway of the bridge is 44 ft. above the railroad on one side and cuts

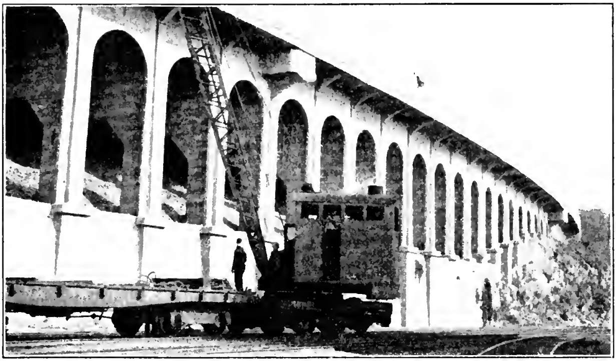

FIG. 12. SECTION 6.

into the bank on the other side. (Figs. 3, 12 and 13 and Plate X.)

## CONTRACTS.

The construction of the bridge was divided into three contracts, A, B and C.

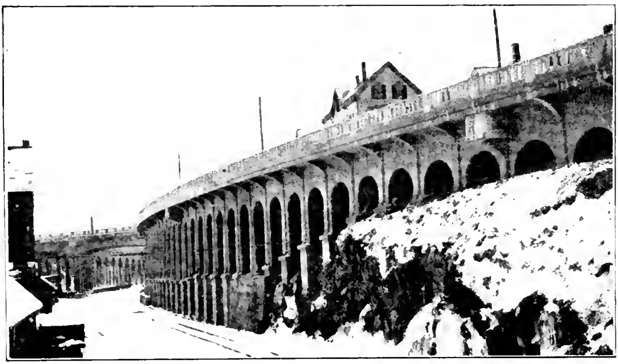

FIG. 13. SECTION 6, LOOKING TOWARDS SECTION 4.

*Contract A.*

Contract A included the fill of Section 1, the foundations of Section 2, the piers of Section 3, the foundations of Section 4 as far as Commercial Street (which was as far as it was necessary to use piles), and the temporary bridge. (Fig. 7.) It was awarded to Holbrook, Cabot & Rollins Corporation.

*Contract B.*

Contract B included the structural steel spans of Section 3 across the harbor, and the Scherzer Rolling Lift Draw. (Figs. 5 and 6, and Plate V.) It was awarded to the Phœnix Bridge Company.

*Contract C.*

Contract C included: in Section 1, the granite block paving on a concrete base, granolithic sidewalks with concrete retaining walls, the reinforced concrete fence and the loaming and seeding of the slopes of the fill; in Section 2, everything above the foundations; in Section 3, the floor slabs, granolithic sidewalks, concrete fence and wood block paving of the roadway; all of Section 4 with the exception of the foundations mentioned before under Contract A; and the whole of Sections 5 and 6. It was awarded to T. Stuart & Son Co.

## Temporary Bridge.

The street railway company's trestle, just east of the old bridge, was largely utilized for a temporary bridge, but opposite the old draw a new trestle was carried out at an angle far enough to allow the temporary draw to swing clear of the old bridge. (Fig. 1.) The trestle had to be widened and planked, and a sidewalk was also provided.

*Construction of Temporary Bridge.*

The greater part of the construction of the temporary bridge was sublet by Holbrook, Cabot & Rollins Corporation to the Bennett Contracting Corporation of Portland, which began driving piles December 7, 1914. The work proceeded rapidly and was completed as far as was possible, without interrupting traffic, on March 12, 1915. The new draw of the temporary bridge had already been shipped by the Boston Bridge Works, and the center portion, together with the part across one channel, had been erected in place. The opposite end had been assembled on a lighter and riveted as far as possible, and, at six o'clock in the morning of March 12, this lighter, with the remaining portion of the draw, was floated into position and the erection completed, thus closing the channel to navigation. All traffic, including the street cars, was maintained over the

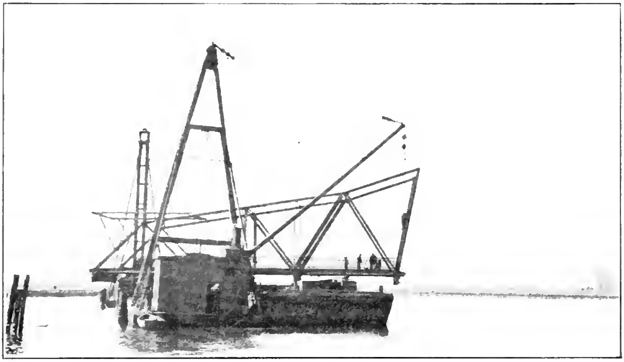

FIG. 14. OLD DRAW SPAN ON LIGHTER.

old bridge until noon, when traffic was interrupted with the exception of pedestrians, and the work of cutting the old drawbridge in two begun. This cutting was done by means of blaw gas, and was completed in an hour and fifty minutes. The portion of the old draw cut off was supported on lighters, and the work of stripping the old draw of rails and woodwork was started. Meantime, the laying of rails and planking on the new bridge was proceeding. At 7.15 P.M. the temporary bridge was ready for use, and the portion of the old draw which had been cut off was floated away. (Fig. 14.) Thus team and electric car traffic was interrupted from noon until 7.15 P.M.,

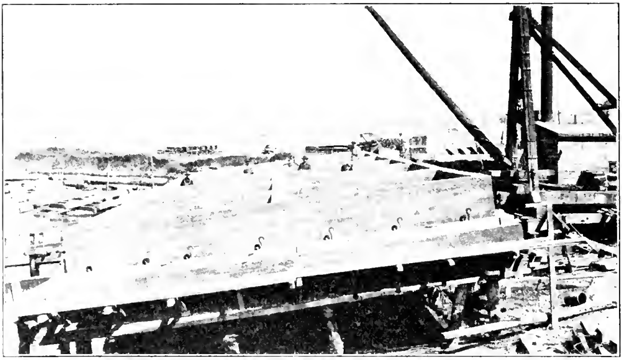

FIG. 15. CAISSON ON LAUNCHING WAYS.

while foot traffic was kept up all day, either across the old bridge or on the new temporary bridge.

## HARBOR PIERS.

The method adopted by the Holbrook, Cabot & Rollins Corporation for building the harbor piers, which occurred in

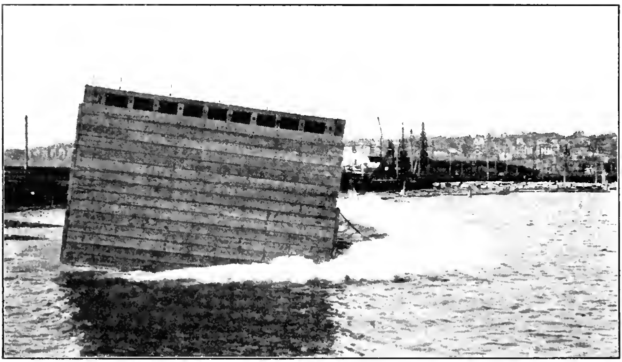

FIG. 16. LAUNCHING CAISSON.

deep water, was interesting and proved very successful. A site was selected just east of the bridge in an enclosed position where a launching-way was built consisting of a platform resting on piles and sloping towards the water. On this platform a bed

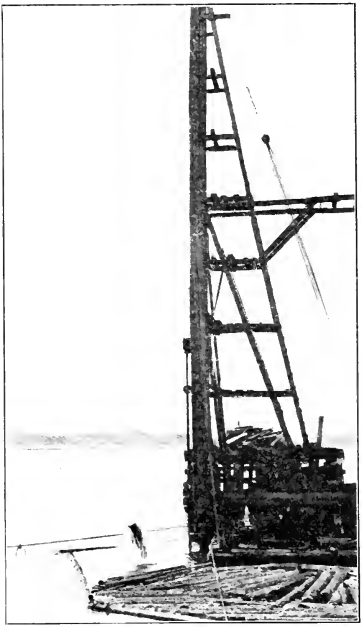

FIG. 17. CUTTING PILES FOR HARBOR PIERS.

of three-inch lagging was laid, corresponding in shape to the bottom of the pier. On this lagging forms were built and a reinforced concrete box constructed, about $4\frac{1}{2}$ ft. deep, having a projecting flange all around the outside, through which projected hook bolts. (Fig. 15.) On this flange wooden sides of 12 by 12 hard-pine posts with 4-in. hard-pine planking on the outside were built up about 18 ft. high. The top timbers were connected by means of rods with the hook bolts anchored in the concrete, and tightly screwed up. The whole structure was then carefully calked and finally launched. (Fig. 16.) This great box or caisson floated high out of water and was towed alongside of a large lighter equipped with a concrete plant and was gradually filled with concrete. On this concrete as a bed, forms of the proper size for the pier were erected within the caisson, and filled with concrete. As the load increased, and the caisson

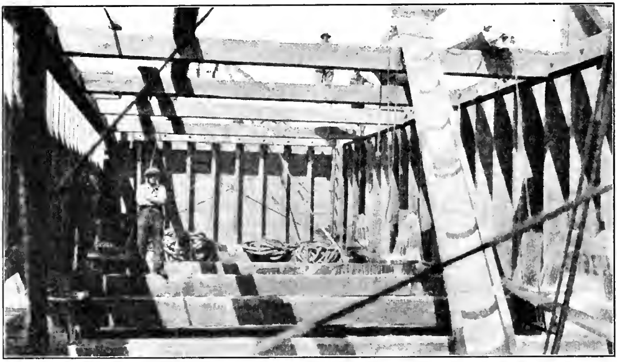

FIG. 18. SINKING CAISSON, WATER BEING ADMITTED.

gradually sank, the sides were twice extended until the total depth reached about 54 ft.

The caisson was then towed to its site which had already been prepared by considerable dredging and by driving piles over the whole area. These piles were cut off quickly by a large circular saw on a vertical shaft carried in the gins of a large pile driver. (Fig. 17.) By means of a level placed on shore, sighting on a white band painted on the vertical shaft carrying the saw, the piles were cut off accurately to grade. The caisson was then filled, until it touched bottom at low tide, when it was very exactly located by means of two transits set up on shore at right angles to each other, and sighting on the two center lines of the caisson. Water was then let into the space between the sides of the caisson and the concrete pier (Fig. 18) until the caisson became so heavy that it would not float again at high water.

Then came the work of building up the concrete to elevation −2, where the granite facing began. This facing was carried up well above high water, the concrete core being carried up simultaneously (Plate IV). The rods connected with the hook bolts at the bottom of the caisson were then loosened and the connections unhooked, allowing the sides to float up to the surface. They were then towed away and used on another caisson. This method permitted all concrete work to be cast dry, and also permitted thorough inspection.

## Reinforced Concrete Construction.

Practically all of the reinforced concrete construction in the bridge was done by T. Stuart & Son Company, of Newton. They began unloading their equipment November 30, and put in a very complete plant consisting of a mill containing electrically driven saws and planes, a large platform adjoining the mill for building forms, and two towers for hoisting concrete to be delivered by chutes to all parts of Sections 4, 5 and 6. The tallest tower was placed directly east of the bridge and near Commercial Street, and was provided with a runway up which teams drew all the materials, which were dumped through traps in the floor of the platform, where they could run by gravity to the mixer at the foot of the tower. The mixer dumped directly into an elevator bucket which could be rapidly raised to a hopper near the top of the tower. This hopper had a valve controlled by one man who allowed the concrete to flow into the chutes as desired. This tower was 155 ft. high and was built of light steel sections. Another similar tower, 105 ft. high, was erected at the foot of Tyng Street (Fig. 3), which is about midway between the main bridge and the end of Section 6. These towers could deliver concrete to all parts of the work except at the ends of Sections 4 and 5, where it was necessary to carry it in buggies. Stuart's contract called for an immense amount of difficult form work, and he used about one million two hundred and fifty thousand feet, board measure, of lumber. Much of this lumber was used over and over again, some of it as many as a dozen times, being always carefully cleaned and oiled.

### Sand and Stone.

All sand and stone for concrete was brought from a gravel pit in South Portland, about a mile from the bridge. This material was all carefully washed at the pit by means of an elaborate mechanical system. The sand was of an unusually good quality, testing well over 100 per cent. of the strength of standard sand, and the stone was well graded in size.

### Cement.

The cement used under Contract C was Allentown, and each carload was tested. No carload failed in the tests. This was also true of the Catskill Alpha used in Contract A.

### Piles.

The piles used for the temporary bridge varied in length from 30 to 80 ft. and were of white pine, yellow pine and spruce. In driving the piles for the center draw pier and draw landings of the temporary bridge it was found necessary to use piles longer than any of those on hand, and the contractor succeeded in getting a lot of white pine piles in Maine, which ran from 70 to 80 ft. in length. The piles for Section 3 varied from 25 to 50 ft. in length after cutting and were practically all hard pine, except for the permanent fender piers, where oak piles were used. The piles for Section 4 varied in length from 15 ft. to 55 ft. and were of hard pine. Piles for the temporary bridge were driven by a drop hammer, while all of those for Sections 3 and 4 were driven by a large steam hammer. All piles were driven to a very hard stratum and had a penetration of about one inch under the drop hammer and of less than $\frac{1}{8}$ in. under the steam hammer for the last few blows. The supporting power of the piles is apparently excellent, as no measurable settlement has occurred.

## Riprap.

The slopes of Section 1 and the foundations of Sections 2 and 3 were protected with riprap (Fig. 4). The riprap for Section 3 varied in size from one-man stone to several tons. The riprap for the slopes of Section 1 consisted of large flat slabs carefully laid to a smooth surface, and the bottom was protected by a toe of riprap about 5 ft. high and 5 ft. wide. There was considerable trouble with this riprap, as the material of the fill upon which it was laid was very fine and was washed out badly by the waves whenever the wind was in the west. It was found necessary to cover up this flat slab riprap with riprap varying in size from small stones up to one-man size. This was piled on top to a depth of about two feet, and has overcome the difficulty.

## Expansion Joints.

Expansion and contraction was carefully provided for throughout the bridge. There are also deflection joints at the ends of the cantilevers.

In Section 2 the expansion joints occur every third span, or 75 ft. apart, and were made by means of a double pier with a break in the center.

In Section 3 the expansion joints occur at the ends of the cantilevers where the link spans are supported, and are 130 ft. 4 ins. apart for a maximum.

In Section 4 the expansion joints are similar to those in Section 3 with a maximum distance apart of 91 ft. 6 ins. This structure being all reinforced concrete, an expansion and deflection joint having three seats was designed and has been proved to work successfully. (Plate VIII.)

In Section 5 the expansion joints occur at the center of every third span, or 49 ft. 5 ins. apart. (Plate IX.)

In Section 6 the expansion joints occur at the center of every other pier, or 25 ft. apart.

All these expansion joints are carried completely through the structure with the exception of the paving in Sections 4, 5 and 6. Here the joints were near together and the amount of motion so small that the paving was simply laid and filled with pitch for a short distance at the joints. The expansion joints in the paving in Sections 2 and 3 are made by means of heavy angle irons built up in the form of Z's, forming a stop against which the paving was laid and covering the opening with a sliding joint.

The expansion joints in the sidewalks were made with cast-iron plates with checkered tops and sliding one upon the other, the plates being anchored into the sidewalk slabs.

## Fence.

All fence for the bridge was made of reinforced concrete 3 ft. 6 ins. high and 7 ins. thick. The fence has openings 9 ins. wide by 22 ins. deep, with semicircular top and with spaces between the openings varying between 6 ins. and 8 ins. The fence was made in panels varying in length from 3 ft. 6 ins. to 10 ft. 3 ins. These panels were cast in sand molds by Simpson Brothers, of Boston, and were shipped to the site by rail. The sidewalk brackets were made in a similar way, also by Simpson Brothers.

## Paving.

The paving at the ends of the bridge where it was laid upon filling consisted of granite blocks. The fill in all cases had plenty of time to become thoroughly settled, and it was further compacted by means of a steam roller. Upon this sub-grade a 6-in. slab of concrete was laid, and then the granite paving with gravel joints was laid on a sand cushion. The whole surface was then thoroughly grouted. The paving over all the rest of the bridge consisted of Jennison-Wright wooden lug blocks, $3\frac{1}{2}$ ins. deep. The surface of the concrete slab upon which the paving was to be laid was covered with a mixture of cement and sand in the proportion of one to four, mixed dry. This was very carefully leveled by means of screed templates, giving a depth of about $\frac{1}{2}$ in. The cushion was then sprinkled with water, the blocks immediately laid and the joints filled with fine, clean sand by sweeping. The whole surface was then thoroughly wet with a hose and carefully brought to a true surface by means of tamping. The sand was allowed to remain upon the paving to a depth of about ½ in. and became thoroughly worked into the joints by traffic. The paving has now been in service for three months and has given practically no trouble and presents a very smooth surface.

### Scuppers.

Cast-iron scuppers were placed along the curb at frequent intervals, and under extremely heavy rains have proved entirely adequate to carry off the water.

### Conduits.

There are a great many lines of wires carried across the bridge, both for telephone and electric light and power. These wires are carried in conduits laid between the double slabs of the sidewalks, manholes being provided at proper intervals to enable the wires to be pulled through. At the draw opening, these wires are carried down in cables through a trench dredged in the bottom of the channel.

### Drawbridge.

The drawbridge is a Scherzer Rolling Lift Draw having two leaves, each approximately 85 ft. long by 60 ft. wide. The counterweights are carried by cross members between the lower ends of the draw trusses, and are well above high water when the draw is opened. These counterweights are made of reinforced concrete, having a large pocket in each. By means of small loose blocks of concrete placed in the pockets, the draw leaves can be correctly balanced under any condition. The draw is operated by electricity and has self-locking jaws. Provision is also made for hand operation in case the electrical equipment should get out of order. In the operating house are small signal lights which show the exact location of the leaves when operated at night. The draw can be opened in a little less than a minute.

### Lights.

The bridge is lighted by double lights, supported by ornamental brackets on each trolley pole; the poles being spaced about 100 ft. apart.

### Personnel.

The bridge was designed by J. R. Worcester & Co., and was erected under their personal supervision, with the writer as resident engineer.

The bridge was built under the charge of the Cumberland County Commissioners, James Carroll Mead, chairman, James H. McDonald and W. F. Pillsbury. Mr. Mead died soon after the contracts were signed, and Mr. McDonald became chairman, the third place on the board being filled by Mr. Charles A. Maxwell.

Contract A was in charge of Mr. L. S. White, superintendent for Holbrook, Cabot & Rollins Corporation; Contract B was in charge of Mr. James Bason, superintendent for the Phœnix Bridge Company; while Contract C was in charge of Mr. Albert T. Stuart, of T. Stuart & Son Co. These three superintendents were all remarkably able men, and conducted the work with great speed and very fine results. Mr. McDonald, chairman of the Commission, took great interest in the work and usually visited the site twice a day.

* * *

### Unit Prices.

| | | |
|---|---|---|
| Sand fill | $0.60 | cu. yd. |
| Cinder fill | .50 | ,, ,, |
| Excavation, Contract C | 1.45 | ,, ,, |
| ,, of sea wall | 2.00 | ,, ,, |
| ,, Contract A | 1.00 | ,, ,, |
| Dredging | .50 | ,, ,, |
| Back fill, Contract C | .20 | ,, ,, |
| Riprap, Contract A | 2.50 to $3.50 | per ton |
| Concrete cast in water | 6.50 | cu. yd. |
| ,, backing | 5.50 | ,, ,, |
| ,, foundations, Section 4 | 7.00 | ,, ,, |
| Reinforced concrete | 8.37 | ,, ,, |
| ,, ,, extra | 15.00 | ,, ,, |

| | |
|---|---|
| Rods for reinforcement | $0.024 to .05 per lb. |
| Wire mesh ,, | .035 per lb. |
| Removing old granite paving | .30 sq. yd. |
| Granite paving on gravel | 2.25 ,, ,, |
| ,, ,, on 6 in. concrete base | 3.25 ,, ,, |
| Granolithic sidewalk on fill | 1.65 ,, ,, |
| Granite curb | .50 per ft. |
| ,, ,, extra | 1.25 ,, ,, |
| ,, ,, curved, extra | 1.50 ,, ,, |
| Lug block paving | 1.65 sq. yd. |
| Metal curb bar | .10 per ft. |
| Pipe fence | .75 ,, ,, |
| Reinforced concrete fence | 1.45 ,, ,, |
| ,, ,, ,, extra | 2.50 ,, ,, |
| Loricated 1-in. pipe | .035 ,, ,, |
| Fiber conduct | .04 ,, ,, |
| Castings | .02 per lb. |
| Trolley base castings | .035 ,, ,, |
| Gravel sidewalk | .60 sq. yd. |
| Paved gutter | .20 lin. ft. |
| Catch basins in fill | 67.00 each |
| Granite facing piers | 21.00 cu. yd. |
| Granolithic finish | .045 sq. ft. |

*Note:* Prices for reinforced concrete do not include forms or equipment.

* * *

### Cost of Spruce or Hard Pine Piles Driven and Cut.

*Section 3.*

| | | |
|---|---|---|
| 25 ft. long | $5.00 each | |
| 25 to 30 ft. long | 5.50 ,, | Driven from floating machine with follower, and cut below water. |
| 30 ,, 35 ,, ,, | 6.85 ,, | |
| 35 ,, 40 ,, ,, | 7.75 ,, | |
| 40 ,, 45 ,, ,, | 9.00 ,, | |
| 45 ,, 50 ,, ,, | 11.25 ,, | |
| 50 ,, 55 ,, ,, | 12.00 ,, | |

*Sections 2 and 4.*

| | | |
|---|---|---|
| 15 ft. long | $4.50 each | |
| 15 to 20 ft. long | 4.75 ,, | |
| 20 ,, 25 ,, ,, | 5.15 ,, | |
| 25 ,, 30 ,, ,, | 5.60 ,, | Driven with land driver and cut above ground. |
| 30 ,, 35 ,, ,, | 6.00 ,, | |
| 35 ,, 40 ,, ,, | 8.00 ,, | |
| 40 ,, 45 ,, ,, | 9.00 ,, | |
| 45 ,, 50 ,, ,, | 11.00 ,, | |
| 50 ,, 55 ,, ,, | 12.00 ,, | |
| 55 ,, 60 ,, ,, | 14.00 ,, | |

| | |
|---|---|
| Finishing concrete surface | \$0.01 sq. ft. |
| Temporary bridge | \$30 000.00 |

STRUCTURAL STEEL.

| | |
|---|---|
| Girder spans erected | \$0.0313 per lb. |
| Truss " " | .0328 " " |
| Draw span erected | .0473 " " |
| Erection of steel work (bolted) | .0068 " " |
| Riveting | .0010 " " |

UNIT STRESSES.

Concrete construction was designed in accordance with the recommendations of the Joint Committee.

Structural steel work was designed in accordance with the specifications of the American Railway Engineers Association.

| | |
|---|---|
| Cost of bridge | \$965 000 |
| Land damages | 76 000 |
| Cost, less land damages | \$889 000 |

# NOTE.

The adoption of a new color for the cover of the JOURNAL has been made necessary by the discontinuance of manufacture of the stock used heretofore.

THE EDITOR.

Vol. III JANUARY, 1916 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, JANUARY 26, 1916,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. W. R. Farrington, Division Engineer of the Massachusetts Highway Commission, will read a paper on "Sand and Oil Roads and Surfaces."

S. E. TINKHAM, *Secretary.*

## PAPERS IN THIS NUMBER.

"The Water Supply of Salem, Mass.," W. S. Johnson.
"Early Types of Turbines," C. W. Sherman.
"Joint Mortar Exposed to Tidal Currents," J. L. Howard.
Discussion of "Special Methods of Reinforced Concrete Design."
Memoirs of deceased members.

### CURRENT DISCUSSIONS.

| Paper. | Author. | Published. | Discussion Closes. |
| --- | --- | --- | --- |
| "South End Sewer System, Boston." | E. S. Dorr. | Dec. | Feb. 10. |



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

## MINUTES OF MEETINGS.

Boston, Mass., December 15, 1915. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple. The meeting was preceded by a dinner, served in the same hall at 6 o'clock, at which 118 members and ladies participated, dinner being followed by a short entertainment.

The business meeting was called to order at 8 o'clock by the President, Charles R. Gow. The total attendance of members and guests, including ladies, was 180.

By vote, the reading of the record of the November meeting was dispensed with and it was approved as printed in the December Journal.

The Secretary reported for the Board of Government the election of the following to membership in the grades named:

Members — Lyman Waldo Bigelow, Nathan Carter Burrill, William Haskins Coburn, John Dana Savage and Charles Norton Taylor.

Juniors — Horatio Whittemore Brown, Joseph Richard Duggan, Gordon Fehr, Howard Leslie Foster, Howard Whipple Green, Frank Bowman Hastie, Thos. Francis McSweeney, John Wm. Shorrock and Ellis Spence Tisdale.

The Secretary announced the death of J. Herbert Shedd, a member of the Society, which occurred November 27, 1915, and by vote the President was requested to appoint a committee to prepare a memoir.

The President then introduced Mr. A. A. Cohill, civil engineer, who read a paper entitled, "The Construction of the Dorchester Tunnel under Fort Point Channel." The paper was illustrated with lantern slides and motion pictures, the latter being furnished by P. McGovern & Co., the contractors for building the tunnel.

After extending a vote of thanks to Mr. Cohill for his kindness in presenting the paper before the Society in such an interesting manner, the meeting was adjourned.

S. E. Tinkham, *Secretary.*

BOSTON, MASS., November 24, 1915. — A special meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in the Society Library. The meeting was called to order at 8 o'clock by the chairman.

The minutes of the November 3d meeting were read and approved.

The chairman then introduced Mr. Harold I. Eaton, chief inspector, Atlantic County, N. J., Mosquito Extermination Commission, who gave a very interesting account of mosquito extermination work in Cuba, Panama and New Jersey. A large number of slides were used to illustrate methods and apparatus. The plan of organization adopted in Atlantic County was described and copies of reports and inspection blanks shown.

The subject was discussed by a number of gentlemen and many questions were asked, indicating considerable interest in this subject.

It was voted to extend to Mr. Eaton the thanks of the Section for his courtesy in presenting the paper of the evening.

In the audience were a number of city officials outside the membership of the Society.

There were 54 present.

Adjourned at 10 o'clock.

FRANK A. MARSTON, *Clerk*.

BOSTON, MASS., December 1, 1915. — A regular meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in Myers Hall, Tremont Temple.

At 6 o'clock a supper was served (buffet style) in the Society library. There were 90 present.

The meeting in Myers Hall was opened at 7.30 o'clock by the chairman. The minutes of the November 24th meeting were read and approved.

The speaker of the evening was Mr. Frederic H. Fay, past president of the Boston Society of Civil Engineers, who gave an illustrated talk on the "Proposed Improvements of the Quequechan River, Fall River, Mass." The problems presented were of an unusual and interesting character. There was some discussion following the talk, and many questions were asked of the speaker.

There were 113 present.

Adjourned at 9 o'clock.

Frank A. Marston, *Clerk.*

## APPLICATIONS FOR MEMBERSHIP.

[January 6, 1916.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Babbitt, John Hancock, Cambridge, Mass. (Age 21, b. Northampton, Mass.) Junior at Mass. Inst. of Technology, civil engineering course; attended Mass. Inst. of Technology Surveying Camp during one summer. Refers to C. B. Breed, G. L. Hosmer, J. W. Howard, A. G. Robbins, G. E. Russell and C. M. Spofford.

Crocker, Henry Lovell, Boston, Mass. (Age 26, b. Yorktown, N. D.) Received technical education at Lowell Inst., mechanical engineering course, and at Franklin Union, course in reinforced concrete and bridge design. From 1908 to 1911, transitman with Aspinwall & Lincoln, Boston; from 1911 to date, assistant with Boston Transit Commission. Elected a junior, September 18, 1912, and now desires to be transferred to grade of member. Refers to E. S. Davis, F. C. H. Eichorn, G. D. Emerson, J. B. Flaws, J. T. Frame and L. B. Manley.

Kleinert, Albert Emanual, Jr., Boston, Mass. (Age 24, b. Brooklyn, N. Y.) Student at Mass. Inst. of Technology, class of 1915. Refers to C. F. Allen, C. B. Breed, H. J. Hughes and L. J. Johnson.

Maynard, Forrest Joseph, Watertown, Mass. (Age 31, b. Lancaster, Mass.) High school education. From 1902 to 1904, with Parker & Bateman, Clinton, Mass.; from 1905 to 1912, with exception of eighteen months on bridge and railway work in West, was assistant engineer on railway surveys and construction in Panama for United Fruit Co.; from 1912 to 1914, in private practice as engineer and surveyor, Watertown, Mass.; since August, 1914, with Edison Co., Boston, St. Engrg. Dept. Refers to F. C. H. Eichorn, J. T. Frame, J. F. A. Giblin, E. L. Johnson and O. F. Mann.

Parker, Robert Emerson, Reading, Mass. (Age 27, b. Reading, Mass.) Graduate of Dartmouth College, 1910, and of Thayer School of Civil Engineering, 1911. From May to Sept., 1910, designer with Boston Elevated Ry. Co., Central Sq. office, Cambridge; from May, 1911, to date, draftsman and designer with Aberthaw Construction Co., Boston; is also inspector of buildings, Reading, Mass. Elected a junior, Jan. 24, 1912, and now desires to be transferred to grade of member. Refers to W. H. Balch, M. F. Brown, J. A. Garrod, A. B. MacMillan and H. F. Sawtelle.

Smith, William Henry, Dedham, Mass. (Age 20, b. Boston, Mass.) Graduate of Mass. Inst. of Technology, 1915, civil engineering course. During summers of 1913 and 1914, and from graduation to date, rodman, draftsman, transitman, etc., with E. Worthington, Dedham. Refers to C. F. Allen, C. B. Breed, J. W. Howard, C. M. Spofford and Erastus Worthington.

## LIST OF MEMBERS.

ADDITIONS.

| | |
|---|---|
| Atwood, Thomas C. | 185 Church St., New Haven, Conn. |
| Barney, Harold B. | 18 Spooner Rd., Chestnut Hill, Mass. |
| Brown, H. Whittemore | Mass. Inst. of Technology, Boston, Mass. |
| Burrill, Nathan C. | 88 Broad St., Boston, Mass. |
| Colby, Edwin W. | 4 St. Botolph St., Boston, Mass. |
| Fehr, Gordon | 11 Irvington St., Suite 2, Boston, Mass. |
| Foster, Howard L. | 3 Greenwood St., Amesbury, Mass. |
| Green, Howard W. | 11 Irvington St., Boston, Mass. |
| Savage, John Dana | 150 Prichard St., Fitchburg, Mass. |
| Shorrock, John W. | 39 Longfellow St., Dorchester, Mass. |
| Taylor, Charles N. | 12 Grove St., Wellesley, Mass. |
| Tisdale, Ellis S. | Mass. Inst. of Technology, Boston, Mass. |
| Wadsworth, George R. | 37 Philbrick Rd., Brookline, Mass. |
| Walker, Frank B. | 86 Bartlett Rd., Winthrop, Mass. |

CHANGES OF ADDRESS.

| | |
|---|---|
| AMBLER, HALFORD H. | Hotel Clayton, Detroit, Mich. |
| BESSEY, ROY F. | 3109 Clarendon Rd., Brooklyn, N. Y. |
| MILNE, ALEXANDER P. | 321 Platt Bldg., Portland, Ore. |
| VAN RENSSELAER, ALLEN | General Delivery, San Francisco, Cal. |
| WHITING, MASON T. | 201 Devonshire St., Boston, Mass. |

DEATHS.

| | |
|---|---|
| ELLSWORTH, EMORY A. | December 8, 1915 |
| RICHARDSON, THOMAS F. | December 26, 1915 |
| SHEDD, J. HERBERT | November 27, 1915 |

## EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### MEN AVAILABLE.

338. Age 22. Graduate of the University of Maine, 1915, with degree of B.S. in civil engineering. Has had six months' experience as detail draftsman on machine parts and factory lay-outs. Desires position as structural draftsman. Salary desired, $18 per week.

339. Age 29. Graduate of Harvard, 1908, with degree of A.B.; received degree of S.B. in civil engineering, 1909. Has had four years' experience as draftsman, estimator, division engineer, etc., on hydro-electric construction; and one year and a half as timekeeper and cashier on paving contracts. Desires position along engineering lines with good chance for advancement. Minimum salary desired, $100 per month.

340. Age 24. Graduate of Worcester Polytechnic Inst., 1914, civil engineering course. Has had one year's experience as instrumentman, including field and office work, with Met. Water Works; six months as transitman on preliminary surveys for highway construction; and one month as draftsman on general building construction with firm of mill engineers and architects.

341. Age 31. Graduate of Mass. Inst. of Technology, civil engineering course, 1905. Has had about ten years' experience, including two years as instrumentman and chief of party on surveys for water-power and flood-prevention projects; five years as designer for water supply, gas and electricity boards; and one and one-half years, to date, on construction of filtration plant. Desires position along hydraulic or sanitary engineering lines. Minimum salary desired, $1,500 per year.

342. Age 28. Graduate of Dartmouth College, with degree of B.S., 1909; senior year in Thayer School of Civil Engineering. Has had about six years' experience as rodman, instrumentman, chief of party, draftsman and assistant engineer on dam construction, boundary surveys, harbor improvements and construction of sewage filtration beds. Desires position as assistant engineer or chief of party upon water supply, sewage disposal, general construction or general surveying work. Salary desired, $125 per month.

343. Age 25. Student for three years at Purdue University, civil engineering course. Has had nearly three years' experience, including two years as draftsman, instrumentman, etc., on railway work; and nine months as foreman and assistant superintendent on water-works construction. Desires position as engineer (field or office work) or as assistant superintendent on construction. Salary desired, $90 per month.

## LIBRARY NOTES.

### Book Review.

**General Specifications for Concrete Work as Applied to Building Construction.** Reviewed by A. B. MacMillan.*

This is the second edition, revised and enlarged, of a work that originally appeared in 1908.

It consists of fifty-six pages about eight and one-half by eleven inches in size. Four pages are given up to title, preface and index, twenty-eight pages to specifications, and twenty-four pages to designing data and tables.

The specifications cover the general subject of concrete, aggregate, proportioning, mixing and placing, finish, protection, forms, reinforcement, etc. Some space is devoted to cast stone, concrete piles and waterproofing.

The formulæ given are the usual straight line formulæ

* Chief Engineer, Aberthaw Construction Co.

for single rectangular beams, tee beams and beams with compression steel. Methods of design for flat slab floors, based on the rulings adopted by the city of Chicago, are included.

In general the pamphlet deals with the various subjects taken up clearly, tersely and reasonably, and should be useful to any one who has to write specification for concrete work.

## Recent Additions to the Library.

**U. S. Government Reports.**

Annual Report of Director of Office of Public Roads for 1914–15.

Annual Report of Governor of Panama Canal for 1914–15, with Maps and Diagrams.

Anticlines in Clinton Sand near Wooster, Wayne County, Ohio. C. A. Bonine.

Production of Bauxite and Aluminum in 1914. W. C. Phalen.

Bibliography of North American Geology for 1914, with Subject Index. John M. Nickles.

Cement Industry in United States in 1914. Ernest F. Burchard.

Some Cinnabar Deposits in Western Nevada. Adolph Knopf.

Cotton Production and Distribution, 1914–15.

Duncan Gas Field, Stephens County, Oklahoma. Carroll H. Wegemann.

Fauna of So-Called Boone Chert, near Batesville, Arkansas. George H. Girty.

Fauna of Boone Limestone at St. Joe, Arkansas. George H. Girty.

Field Apparatus for Determining Ash in Coal. C. E. Lesher.

Fractional Precipitation of Some Ore-Forming Compounds at Moderate Temperatures. Roger C. Wells.

Geology and Oil Resources of West Border of San Joaquin Valley North of Coalinga, California. Robert Anderson and Robert W. Pack.

Gold Deposits near Quartzsite, Arizona. Edward L. Jones, Jr.

Gold, Silver and Copper in Alaska in 1914. Alfred H. Brooks.

Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1914. Charles W. Henderson.

Gold, Silver, Copper, Lead and Zinc in Eastern States in 1914. J. R. Dunlop.

Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1914. Charles W. Henderson.

Production of Graphite in 1914. Edson S. Bastin.

Healdton Oil Field, Carter County, Oklahoma. C. H. Wegemann and K. C. Heald.

Lawton Oil and Gas Field, Oklahoma. Carroll H. Wegemann and Ralph W. Howell.

Production of Lime in 1914. G. F. Loughlin.

Loco Gas Field, Stephens and Jefferson Counties, Oklahoma. Carroll H. Wegemann.

Latitude Observations with Photographic Zenith Tube at Gaithersburg, Md. Frank E. Ross.

Production of Manganese and Manganiferous Ores in 1914. D. F. Hewett.

Mineral Resources of Alaska. Alfred H. Brooks.

Production of Mineral Waters in 1914. R. B. Dole.

Notes on Use of Low-Grade Fuel in Europe. R. H. Fernald.

Possibilities of Oil in Porcupine Dome, Rosebud County, Montana. C. F. Bowen.

Reconnaissance for Oil near Quanah, Hardeman County, Texas. Carroll H. Wegemann.

Orofino Coal Field, Idaho. Charles T. Lupton.

Reconnaissance in Palo Pinto County, Texas, with Special Reference to Oil and Gas. Carroll H. Wegemann.

Phosphate Deposits of Florida. George Charlton Matson.

Potash Salts: Summary for 1913. W. C. Phalen.

Quicksilver in 1914. H. D. McCaskey.

Production of Salt, Bromine and Calcium Chloride in 1914. W. C. Phalen.

Production of Sand and Gravel in 1914. G. F. Loughlin.

Results of Spirit Leveling in Arizona, 1899 to 1915, inclusive. R. B. Marshall.

Results of Spirit Leveling in Missouri, 1896 to 1914, inclusive. R. B. Marshall.

Uniform Accounts for Systems of Water Supply, 1911.

Water-Supply Papers 332-B, 340-L, 352, 362-C, 375-E and F.

**State Reports.**

Maine. Annual Reports of Water Storage Commission for 1910–13.

New Hampshire. Annual and Statistical Report of Public Service Commission for 1913–14.

New York. Annual Report of Public Service Commission for First District for 1913: Vols. III–V.

**Municipal Reports.**

Baltimore, Md. Report of Topographical Survey Commission for 1910.

Chicago, Ill. Annual Report of Department of Public Works for 1913.

**Miscellaneous.**

American Railway Master Mechanics' Association: Proceedings for 1905–12 and for 1914. Gift of Fred M. Twombly.

American Sewerage Practice, Vol. III: Disposal of Sewage. Leonard Metcalf and Harrison P. Eddy. Gift of the authors.

Association of American Portland Cement Manufacturers: Concrete House and Its Construction; Concrete in the Country; Concrete School Houses; Concrete Silos; Concrete Surface Finish; Concrete Tanks; Concreting in Winter; Factories and Warehouses of Concrete; Manual Training Course in Concrete; Portland Cement Stucco; Reinforced Concrete Chimneys; Reinforced Concrete Poles; Standard Methods of Testing and Specifications for Cement.

Engineering Index for 1915.

The attention of members is called to the fact that among the books bequeathed to the Society by the late Edmund K. Turner is a copy of Emerson's "Hydro-Dynamics." Members will perhaps recall that some time ago your Committee asked for information as to where a copy of this book might be obtained.

One of our members has suggested that the annual reports of the Wisconsin Railroad Commission be added to the library. The Commission has supplied us with the fourth, fifth, sixth and seventh reports, for the years 1910 to 1913, inclusive. Information as to where the remaining reports can be obtained would be appreciated.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

**United States Government.** — NAVY DEPARTMENT. — *Navy Yard, Boston.* — The construction of a steel and concrete fireproof floor in pattern shop, Building No. 42.

**Commonwealth of Massachusetts.**—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.*

*Bellevue Reservoir.* — The construction of the masonry tower on Bellevue Hill in West Roxbury is completed, with the exception of the roof, work on which is in progress during favorable weather.

*Pipe Lines.*—The work of laying the 60-in. Weston aqueduct supply mains in Commonwealth Avenue, Newton, has been completed.

*Sudbury Power Plant.*— The work of constructing the surge tanks and preparing the foundations and wheel pits for the hydroelectric plant at Sudbury Dam in Southborough has been completed. The plant which is to be installed includes three vertical shaft hydraulic turbines directly connected to one 900 K.V.A. and two 275 K.V.A., A. C. generators. The work of erecting the machinery will be in progress the latter part of the month.

*Sewerage Works.* — Work is in progress on Sect. 106, the Wellesley extension sewer; on Sect. 1A, the outfall sewer at Deer Island, and on Sect. 19, the Malden River Siphon.

Work contemplated includes Sections 103 and 104, Wellesley extension sewer, for which contracts have been awarded and on which work will soon be started; and Sect. 1, Deer Island outfall, contract for which will be prepared in order to start work in the spring.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Charles River Reservation.* — The work of building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown, has been begun. A. G. Tomasello, contractor.

Plans are being prepared for bridge over the Charles River at Commonwealth Ave., between Newton and Weston, and bids will be asked for the work before spring.

Work of excavating channel of Charles River from Elm St. to Bleachery Dam, Waltham, is in progress. John R. Burke, contractor.

*Furnace Brook Parkway.* — Work of construction of parkway extension from Quincy Shore Reservation to Hancock St. is in progress. John Cashman & Sons Co., contractor.

Work of building reinforced concrete girder bridge across Blacks Creek, for Furnace Brook Parkway Extension, is in progress. Hugh Nawn Contracting Co., contractor.

*Mystic Valley Parkway.* — Work of excavating the channel of Aberjona River from Boston & Maine Railroad Bridge to Waterfield St. is in progress. Coleman Brothers, contractors.

**Boston Transit Commission.** — *Dorchester Tunnel.* — Descriptions of Sections D, E, G and H were printed in the JOURNAL in October and December, 1915.

No change is reported in the status of Sect. D.

In Sect. E both shields are under the channel, the one for the easterly tunnel being several hundred feet in advance of that for the westerly tunnel.

Work was begun on Sect. G on Nov. 29, 1915. Tunneling under Dorchester Ave. near B St. for the 3 ft. x 5 ft. intercepting sewer is in progress; also excavation for the pump well at A St., the bottom of which will be 50 ft. below the surface of the street. The excavation for the incline for surface cars between A St. and West Fourth St. is also in progress.

The car tracks of the Boston Elevated Railway Company have been diverted from Dorchester Ave. between Andrew Sq. and West Fourth St.

On Sect. H the excavation has been nearly completed.

**City of Boston.** — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

| | | |
|---|---|---|
| East First St., | from West First St. to H St. | Granite block. |
| Orleans St., | from Grove St. to Porter St. | Concrete base. |
| Gladstone St., | from Walley St. to Upland St. | Artificial stone sidewalk. |
| Lake St., | from Commonwealth Ave., 1 720 ft. northerly. | Tar macadam. |
| Cornell St., | from Orange St. to Colberg Ave. | Concrete base. |
| Montebello Rd., | from Forest Hills St. to Walnut Ave. | Bitulithic. |
| Spring St., | at hospital grounds. | Fence. |
| Poplar St., | from Sycamore St. to Brown Ave. | Artificial stone sidewalks. |
| Morton St., | from Washington St. to N. Y., N. H. & H. R. R. | Concrete base. |
| Hill Top St., | from Granite Ave. to Hallet St. | Grading. |
| Harvard St., | from Morton St. to Deering Rd. | Concrete base. |
| Dunlap St., | from Washington St. to Whitfield St. | Concrete base. |
| Upland Ave., | from Park St. to Melville Ave. | Concrete base. |
| Rosewood St., | from Oakland St. to Randolph Rd. | Asphalt macadam. |
| Brunswick St., | from Blue Hill Ave. to Normandy St. | Concrete base. |
| Randall St., | from Harrison Ave. to Albany St. | Concrete base. |
| Worthington St., | from Longwood Ave. to the Fenway. | Concrete base. |

**Boston Elevated Ry. Co.** — *Bureau of Elevated & Subway Construction.* — The Company is completing at Harvard Sq. an escalator having a rise of about 22 ft. 6 in. from the second level of the surface platforms to the street level, to accommodate passengers arriving on both the upper and lower level surface-car platforms. The escalator is of the Reno or cleat type, and will be completed on or about the middle of January, 1916.

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Seventeen submarine boats.

Torpedo boat destroyers 63, 64 and *Tucker.*

Oil tankers *Texas* and *New York.*

Cargo vessel *Cubadist.*

Freight steamers *Edward Luckenbach* and *Julia Luckenbach.*

Molasses steamers *Sucrosa* and *Mielero.*

Two freight steamers for the Texas Company.

Two additional freight steamers for the Luckenbach Company.

One oil boat for the Government of Argentine.

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Professor Lowell reports two new canals on Mars, but he does not tell our engineers how the Martian mudhogs handle slides and tidewash. — *Boston Herald.*

Vol. III FEBRUARY, 1916 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, FEBRUARY 16, 1916,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Edward C. Sherman will present a paper, illustrated with lantern slides, on "The Spillways of the Panama Canal."

S. E. TINKHAM, *Secretary*.

## PAPERS IN THIS NUMBER.

"Sand and Oil Roads and Surfaces," W. R. Farrington.

"Some Minor Problems in a Highway Bridge Design," L. M. Hastings.

"Pan-American Use of the Metric System," Fred. Brooks.

"Discussion of Federal Valuation of the Boston and Maine Railroad."

### CURRENT DISCUSSION.

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "Water Supply of Salem." | W. S. Johnson. | Jan. | March 10 |

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

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Members who wish to buy copies of the "surprise" provided by the Committee on Social Activities at the informal dinner on January 26 should notify the Editor at once. It will be typewritten or printed, depending on the number of copies ordered, and the cost ought not to exceed 10 cents a copy.

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## MINUTES OF MEETINGS.

Boston, Mass., January 26, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8.20 o'clock by the Senior Vice-President, Richard A. Hale. There were present 92 members and visitors.

By vote the reading of the record of the last meeting was dispensed with and it was approved as printed in the January Journal.

The Secretary reported for the Board of Government that it had elected to membership, in the grades named, the following candidates:

Members — Frank W. Johnson, Jacob M. Sokoll, Leslie W. Snow and Albert L. Upham.

Junior — Frank E. Peacock.

He also announced that the Board had elected to Honorary Membership, Past President Frederic Pike Stearns.

On motion of Mr. Harrison P. Eddy, it was voted that the Chair be requested to appoint a committee of three to suggest to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The Chair appointed, as that committee, Messrs. Louis F. Cutter, John C. Chase and Frederic I. Winslow. Later in the meeting that committee suggested the following names for members of the nominating committee, and by vote they were elected: Messrs. Henry B. Wood, David A. Harrington, Henry T. Stiff, John L. Howard and Henry A. Varney.

The Secretary announced the deaths of the following members: Emory A. Ellsworth, died December 8, 1915; Thomas F. Richardson, died December 26, 1915, and S. Foster Jaques, died January 8, 1916. By vote the President was requested to appoint committees to prepare memoirs.

The chairman then introduced Mr. William R. Farrington, division engineer of the Massachusetts Highway Commission, who read a paper entitled, "Sand and Oil Roads and Surfaces."

The Secretary read communications from Mr. Austin B. Fletcher, highway engineer of the California Highway Commission; Mr. Charles M. Upham, chief engineer, Coleman du Pont Road, Inc., Georgetown, Del.; and Mr. Logan Waller Page, director, Office of Public Roads and Rural Engineering of the United States Department of Agriculture. Mr. W. P. Hammersley, superintendent of streets of New Bedford, also read a discussion of Mr. Farrington's paper, and Mr. John M. Keyes, road commissioner of Concord, Mass., discussed the paper briefly.

After passing a vote of thanks to Mr. Farrington for his very interesting paper, the Society adjourned.

S. E. Tinkham, *Secretary.*

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## BINDING SOCIETY JOURNAL.

The Secretary has made arrangements for binding Volume II of the Journal of the Society. The ten numbers will be bound in one volume, the style of binding to be uniform with that of last year. The price for this binding is 70 cents per volume.

Numbers for binding must be sent to 715 Tremont Temple, Boston, before March 1, 1916, in order to be bound at the price named.

## APPLICATIONS FOR MEMBERSHIP.

[February 1, 1916.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BEAN, THOMAS WEBSTER, Turners Falls, Mass. (Age 29, b. So. Hadley Falls, Mass. Graduate of Mass. Agricultural College, 1909, civil engineering course. From 1909 to 1911, with Warren H. Manning Co., Boston; from 1911 to date, civil engineer with Turners Falls Power and Electric Co.; in charge of topographical survey on Connecticut River between Turners Falls, Mass., and Vernon, Vt.; at present engineer on storage propositions. Refers to J. R. Baldwin, C. W. Hazelton, C. I. Hosmer and H. A. Moody.

BREEN, CHARLES HENRY, Ware, Mass. (Age 26, b. Ware, Mass. Student for two years in civil engineering course at Case School of Applied Science, Cleveland, Ohio, and for two years at Mass. Inst. of Technology; graduate of latter institution, 1912. From 1912 to date, with exception of three months with Mass. Highway Comm. and private engineer, has been employed by Mass. Harbor and Land Comm., with which commission he now holds position of transitman. Refers to C. F. Allen, L. H. Bateman, C. B. Breed, C. M. Spofford, W. F. Williams and H. B. Wood.

CROSS, RALPH UPTON, Tufts College, Mass. (Age 23, b. Worcester, Mass. Student, Tufts College Engineering School. During past six summer vacations has worked for E. J. Cross Co., of Worcester, on building construction. Refers to H. P. Burden, S. L. Conner, E. H. Rockwell, F. B Sanborn and R. C. Smith.

FARRELL, FRANCIS BERNARD, Roxbury, Mass. Age 33, b. Kentville, Nova Scotia. Graduate of Worcester Polytechnic Inst., 1913, civil engineering course, degree of B.S. During vacations and previous to college course, worked for such firms as J. W. Bishop Co., H. L. Hemenway Co., and B. W. Neil of Brookline, on construction work; since graduation has been with Stone & Webster Engrg. Corp'n on new Technology buildings. Refers to H. M. Allen, B. S. Brown, A. W. French, A. J. Knight and F. B. Sanborn.

HOOD, RALPH DUTTON, Haverhill, Mass. Age 41, b. Topsfield, Mass. Educated in public schools and at Phillips Andover Academy. From 1890 to 1892, rodman, draftsman and transitman; from 1893 to 1895, surveyor for various public service works; from 1895 to 1896, location engineer, Haverhill, Georgetown & Danvers St. Ry.; from 1897 to 1899, chief engineer, Franklin Construction Co.; from 1899 to 1902, with Massachusetts Construction Co.; during 1903, chief engineer, National Construction Co.; from 1904 to 1905, office engineer, El Paso and Durango; during 1906, engineer, New England Breeders' Club; during 1907, with National Railway Construction Co.; from 1908 to 1910, engineer with New Hampshire El. Rys. Co.; during 1911, superintendent of highways, Haverhill; during 1913, with Municipal Council, Haverhill Department of Streets and Highways; from 1914 to date, engineer, maintenance of way, Mass. Northeastern St. Ry. Co. Refers to A. W. Dean, R. R. Evans, Gilbert Hodges and A. D. Marble.

LEWIS, GEORGE WALLACE, Boston, Mass. Age 26, b. Waltham, Mass. Graduate of Harvard College, 1911, degree of B.S. From 1910 to date, engineer with Hugh Nawn Contracting Co. Elected a Junior June 21, 1911, and now desires to be transferred to grade of Member. Refers to H. T. Fernald, Hugh Nawn, L. L. Street and W. O. Wellington.

LUTHER, ROYAL, Portland, Me. Age 61, b. Fall River, Mass. Received technical education from private teachers and at evening school, these studies being supplemented by practical experience as helper at various mechanical trades and apprenticeship of several years to contractor and builder. From 1875 to date, with U. S. Lighthouse Service, in which service he now holds position of superintendent; among important works with which he has been identified are the Graves Lighthouse, Boston Bay, Mass., and Ram Island Ledge, Portland Harbor, Me. Refers to E. P. Adams, T. T. H. Harwood, F. E. Tibbetts, G. H. Towle, J. H. Wallace and H. E. Warren.

PEABODY, DEAN, Jr., Reading, Mass. Age 27, b. Reading, Mass. Graduate of Mass. Inst. of Technology, 1911, degree of S.B., mechanical engineering course. From September, 1911, to June, 1913, assistant instructor in mechanical engineering, and from June, 1913, to date, instructor in applied mechanics and testing materials, Mass. Inst. of Technology; during summer of 1911, timekeeper for Aberthaw Construction Co.; summer of 1912, draftsman with New England Concrete Construction Co.; summer of 1913, draftsman with Lockwood, Greene & Co.; summer of 1914, draftsman with Stone & Webster Engrg. Corp'n. Refers to H. W. Hayward, A. B. MacMillan, E. F. Miller and W. H. Sears.

TURNER, JOHN MATHES, Brookline, Mass. (Age 19, b. Mobile, Ala.) Student at Y. M. C. A. evening school during winter of 1912–13; since September, 1914, has been student at Lowell Inst., buildings course. From July 1, 1912, to date, with Brookline Engrg. Dept., as rodman and transitman. Refers to W. A. Devine, H. W. French, H. W. Hayward, F. A. Leavitt, H. A. Varney and C. J. Wallace.

WHITNEY, RALPH EDWARD, Boston, Mass. (Age 25, b. Keene, N. H.) Graduate of Dartmouth College, 1912, degree of B.S., and of Thayer School of Civil Engrg., 1913, degree of C.E. From May, 1913, to date, draftsman and resident engineer on construction with Robert Spurr Weston. Refers to J. M. Cashman, A. L. Gammage. F. L. Preble, G. A. Sampson, J. P. Wentworth and R. S. Weston.

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## LIST OF MEMBERS.

### ADDITIONS.

ALEXANDER, CLAYTON C. .......... Mt. Auburn Cemetery, Cambridge, Mass.
BIGELOW, LYMAN W. .......... Rm. 15, Bigelow Block, Norwood, Mass.
BURLEIGH, WILLARD G. .......... 20 Chandler St., Waverley, Mass.
DUGGAN, JOSEPH R. .......... 1 West St., Milford, Mass.
HASTIE, FRANK B. .......... 1067 Beacon St., Brookline, Mass.
PITCHER, SAMUEL H. .......... 418 Main St., Worcester, Mass.

### CHANGES OF ADDRESS.

BROWN, T. MORRIS. .......... 600 Main St., East Orange, N. J.
CUMMINGS, W. WARREN. .......... 15 Winter St., Woburn, Mass.
FARLEY, WM. F. .......... 249 Bacon St., Waltham, Mass.
JERRETT, ROBERT .......... 103 Whitmarsh St., Providence, R. I.
JOY, C. FREDERICK, Jr. .......... 61 Shurtleff St., Chelsea, Mass.
KNOWLTON, ARTHUR W. .......... 25 Beach St., Rockport, Mass.
LOUD, RALPH W. .......... 427 Broadway, Cambridge, Mass.
MORRILL, FRED W., Care of Ferro Concrete Construction Co., Cincinnati, Ohio
PIERCE, CHARLES H. .......... Custom House Bldg., Boston, Mass.
ROBINSON, HAROLD L. .......... 103 June St., Worcester, Mass.

### DEATH.

JAQUES, S. FOSTER .......... Jan. 8, 1916

## EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### Men Available.

316. Age 29. Student for three years in civil engineering courses at Harvard Univ.; student in evening courses in mechanical and electrical engineering at Mass. Inst. of Technology. Is junior member of Am. Soc. C. E. and associate member of Am. Inst. E. E. Experience includes one year as transitman of Metropolitan Water and Sewerage Bd. and six years on electric railway work as draftsman, chief of party, resident engineer, superintendent of underground construction, etc. Desires position in line with this experience.

329. Age 23. Graduate of Mass. Inst. of Technology, 1914, civil engineering course. Experience consists of four months as building inspector with American Tel. & Tel. Co., and fourteen months with U. S. Coast and Geodetic Survey on hydrography, leveling, plotting, etc. Desires position with railroad contractor or consulting engineer. Salary desired, $75 per month.

344. Age 22. Graduate of Manual Training High School, New Orleans, La.; student for three years at Tulane University, New Orleans, and for one year at Mass. Inst. of Technology. Has had three months' experience in valuation department of Boston & Albany R. R. Desires position as rodman or chainman. Salary desired, $65 per month.

345. Age 22. Student for two years at Boston Y. M. C. A. Co-operative Engineering School. Has had over two and one-half years' experience as rodman and transitman. Desires position along engineering lines. Salary desired, $15 per week.

347. Age 23. Graduate of Worcester Polytechnic Inst., degree of B.S., civil engineering course. Has had over a year's experience in designing and estimating for civil engineering firm; experience also includes drafting and surveying. Desires position as designer or estimator; is especially interested in concrete and steel work. Salary desired, $75 per month.

## LIBRARY NOTES.

### Recent Additions to the Library.

**U. S. Government Reports.**

Production of Abrasive Materials in 1914. Frank J. Katz.

Manufacture and Uses of Alloy Steels. Henry D. Hibbard.

Annual Report of Director of Bureau of Mines for 1914–15.

Annual Report of Interstate Commerce Commission for 1915, Part I.

Annual Report of Superintendent of Coast and Geodetic Survey for 1914–15.

(The) Ashes: Their Characteristics and Management. W. D. Sterrett.

Production of Asphalt, Related Bitumens, and Bituminous Rock in 1914. John D. Northrup.

Broad Pass Region, Alaska. Fred H. Moffit.

Statistics of Clay-Working Industries in United States in 1914. Jefferson Middleton.

Preliminary Report on Diffusion of Solids. C. E. Van Orstrand and F. P. Dewey.

Ellamar District, Alaska. S. R. Capps and B. L. Johnson.

Erosian Intervals in Eocene of Mississippi Embayment. Edward Wilber Berry.

Evaporation of Potash Brines. W. B. Hicks.

Production of Feldspar in 1914. Frank J. Katz.

Gems and Precious Stones in 1914. Douglas B. Sterrett.

Gold, Silver, Copper, Lead, and Zinc in California and Oregon in 1914. Charles G. Yale.

Gold, Silver, Copper, Lead, and Zinc in Colorado in 1914. Charles W. Henderson.

Notes on Geology of Gravina Island, Alaska. Philip S. Smith.

Iron Ore in Cass, Marion, Morris, and Cherokee Counties, Texas. Ernest F. Burchard.

Iron-Bearing Deposits in Bossier, Caddo and Webster Parishes, Louisiana. Ernest F. Burchard.

Age of Ocala Limestone. Charles Wythe Cooke.

Production of Magnesite in 1914. Charles G. Yale and Hoyt S. Gale.

Methods for Examination of Bituminous Road Materials. Prévost Hubbard and Charles S. Reeve.

Results of Observations Made at Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Maryland, 1913 and 1914.

Statement made by Secretary of War to Committee on Military Affairs of House of Representatives, 1916.

Secretary of War Garrison's Explanation of Military Policy Recommended by him and Approved by President.

Modern Soldier Cannot be Made in a Day. Henry Breckinridge.

Potash in Certain Copper and Gold Ores. B. S. Butler, Ed.

Portland Cement Materials and Industry in United States. Edwin C. Eckel.

Production of Platinum and Allied Metals in 1914. James M. Hill.

Quicksilver Deposits of Mazatzal Range, Arizona. F. L. Ransome.

Reconnaissance in Kofa Mountains, Arizona. Edward L. Jones, Jr.

Rhode Island Coal. George H. Ashley.

Trenching Machinery Used for Construction of Trenches for Tile Drains. D. L. Yarnell.

Water Power Projects, Telephone, Telegraph, Power Transmission Lines on National Forests.

Water-Supply Papers 354, 355, 358, 370, 373, 376–379, 388.

Willow Creek District, Alaska. Stephen R. Capps.

Willows: Their Growth, Use and Importance. George N. Lamb.

**State Reports.**

Massachusetts. Annual Report of Public Service Commission for 1915 (advance copy).

Massachusetts. Reports of Directors of Port of Boston as follows: In re Dry Dock, 1915; Use and Benefits to Massachusetts Manufacturers and Wage Earners of American Merchant Marine, 1915; Analysis of Present Foreign Trade of United States, 1916.

New Jersey. Annual Report of Board of Health for 1914.

New York. Report of State Department of Health on Disposal of Human Excreta and Sewage of Country Home, 1915.

West Virginia. Wood-Using Industries, 1914. J. C. Nellis and J. T. Harris.

Wisconsin. Geography of Fox-Winnebago Valley. Ray Hughes Whitbeck.

**Municipal Reports.**

Detroit, Mich. Annual Report of Department of Parks and Boulevards for 1915.

Hartford, Conn. Annual Report of Water Commissioners for 1914–15.

Providence, R. I. Annual Report of Department of Public Works for 1915.

Salem and Beverly, Mass. Annual Report of Water Supply Board, June, 1913, to September, 1915.

**Miscellaneous.**

American Institute of Mining Engineers: Transactions for 1915, Vol. LI.

American Society of Civil Engineers, Transactions for 1915, Vol. LXXIX, 1915.

Berger Mfg. Co.: Fire, Water and Load Tests on Berger's Metal Lumber System.

General Specifications for Concrete Work. Wilbur J. Watson. Gift of McGraw-Hill Book Co.

Master Car Builders' Association: Proceedings for 1915, 2 vols.

National Board of Fire Underwriters: Report on Congested Dwelling and Tenement Districts in Cities and Towns in Massachusetts; Reports on following cities: Albany, N. Y.; Amsterdam, N. Y.; Atlantic City, N. J.; Battle Creek, Mich.; Bay City, Mich.; Bayonne, N. J.; Bridgeport, Conn.; Brockton, Mass.; Buffalo, N. Y.; Cedar Rapids, Ia.; Chester, Pa.; Cincinnati, O.; Decatur, Ill.; Des Moines, Ia.; Erie, Pa.; Fall River, Mass.;

Fresno, Cal.; Green Bay, Wis.; Harrisburg, Pa.; Haverhill, Mass.; Kalamazoo, Mich.; Lawrence, Mass.; Louisville, Ky.; Lowell, Mass.; Lynn, Mass.; Malden, Mass.; Manchester, N. H.; Nashville, Tenn.; New Bedford, Mass.; North Tonawanda, N. Y.; Norwich, Conn.; Peoria, Ill.; Pittsburgh, Pa.; Portsmouth, Va.; Providence, R. I.; Roanoke, Va.; Rochester, N. Y.; Rockford, Ill.; Saginaw, Mich.; San Francisco, Cal.; Springfield, Ill.; Troy, N. Y.; Williamsport, Pa.; Wilmington, Del.

National Electric Light Association: Handbook on Overhead Line Construction; Proceedings for 1915, Hydro-Electric and Transmission and Technical Sessions; Proceedings for 1915, New England Section. Gift of W. B. Conant.

New International Encyclopædia, Vols. 17 and 18.

Principles and Practice of Surveying, 2 vols. Charles B. Breed and George L. Hosmer. Gift of the authors.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

**Commonwealth of Massachusetts.**— METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work is in progress on Sects. 104 and 106, the Wellesley extension sewer; and on Sect. 1A, the outfall sewer at Deer Island.

Work contemplated includes Sect. 103, Wellesley extension sewer, for which contract has been awarded and on which work will be started March 1, and other sections of the Wellesley extension.

METROPOLITAN PARK COMMISSION. — The following work, in addition to that reported in the January JOURNAL, is in progress:

*Old Colony Parkway.* — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old Neponset Bridge.

**Boston Transit Commission.** — *Dorchester Tunnel.* — Descriptions of Sections D, E, G and H were printed in the JOURNAL in October and December, 1915.

No change is reported in the status of Section D.

In Section E both shields are under the channel, the one for the easterly tunnel being several hundred feet in advance of that for the westerly tunnel.

On Section G, excavation by tunneling for the 3 ft. by 5 ft. and 4 ft. 9 in. by 5 ft. 6 in. intercepting sewer in Dorchester Ave. is completed for a length of about 400 ft., or for about two thirds of the total length. About 60 lin. ft. of the lower half of the reinforced concrete sewer is in place.

Excavation for the pump well at B St. and for the incline between West Fourth and B Sts. in Dorchester Ave. is completed.

Excavation has been started, west of the incline, for the main tunnel, the bottom of which is to be about 43 ft. below the surface of the street. Tongued and grooved sheeting is being driven.

The excavation for Section H has been practically finished. The construction of the tunnel has been substantially completed with the exception of about 50 ft. at the southerly end of the section, a pump well at D St. and a ventilating chamber and emergency exit near Woodward St.

**City of Boston.** — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Construction work has been suspended on account of unfavorable weather.

Vol. III MARCH, 1916 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

## SIXTY-EIGHTH ANNUAL MEETING.

The annual meeting of the Boston Society of Civil Engineers will be held at the Boston City Club, Ashburton Place, Boston, on Wednesday, March 15, 1916.

As previously announced, the annual meeting this year will consist of three principal features: a business meeting at noon, the annual dinner in the afternoon and the smoker in the evening.

### Program.

*Business Meeting.* — The annual meeting required by the Constitution will be called to order at 12 o'clock M. in the Assembly Room on the third floor of the Club House.

*Business.* — Announcement of the election of new members.

To receive the annual reports of the Board of Government, of the Treasurer and of the Secretary.

To receive the annual reports of the several special committees.

To reappoint the several special committees.

Announcement of the result of letter-ballot for officers for the ensuing year.

Presentation of the Desmond FitzGerald Medal.

Address of the retiring President.

*Annual Dinner.* — The thirty-fourth annual dinner will be served at half past one o'clock P.M., in the main banquet hall or auditorium on the fourth floor of the Club House.

At three o'clock Dr. Charles H. Tyndall, of Mount Vernon, N. Y., will deliver a lecture on " The Wonders of Ether Waves " and " Radium and Its Mysteries."

*Smoker.* — The usual informal smoker will be held in the evening in the main banquet hall, beginning at 6.30 o'clock.

S. E. Tinkham, *Secretary.*

## PAPERS IN THIS NUMBER.

" Power Estimates from Stream Flow and Rainfall Data," Dana M. Wood.

" Cleaning Lock Gate Trackways at Charles River Dam," Edward C. Sherman.

" Monkey Cart," E. F. Rockwood.

### Current Discussion.

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| " Sand and Oil Roads and Surfaces." | W. R. Farrington. | Feb. | April 10. |



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

## MINUTES OF MEETINGS.

Boston, Mass., February 16, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Charles R. Gow. There were 106 members and visitors present, including many members of the Boston Section of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers, who had been invited to join in the meeting.

By vote, the reading of the record of the last meeting was dispensed with and it was approved as printed in the February JOURNAL.

The Secretary reported for the Board of Government that it had elected to membership in the grades named:

Members — Henry Lovell Crocker, Thomas C. Davis, Forrest Joseph Maynard and Robert Emerson Parker.

Juniors — John Hancock Babbitt, Albert Emanual Kleinert, Jr., and William Henry Smith.

The Secretary announced the death of John H. Gerrish, an Associate of the Society, who died February 7, 1916. By vote, the President was requested to appoint a committee to prepare a memoir.

The Secretary stated that the date for holding the regular meeting in April would fall this year on the nineteenth of that month. By vote, the day on which the April meeting should be held was left with the Board of Government.

Mr. Edward C. Sherman read the paper of the evening entitled, "The Spillways of the Panama Canal." The paper was illustrated with lantern slides.

A short discussion followed, in which Messrs. L. K. Rourke, H. A. Miller and others took part.

Adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., January 5, 1916. — A regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in Gilbert Hall, Tremont Temple.

A cafeteria supper was served at six o'clock, to 80 members and guests.

The meeting was called to order by the chairman, Stephen DeM. Gage, at 7.30 o'clock.

The speaker of the evening was Major James F. Hall, Medical Corps, U.S.A., and Inspector-Instructor, Sanitary Troops of New England Militia, who gave an illustrated talk on sanitary work in the United States Army.

There were 122 present at the meeting. Adjourned at 9.30 P.M.

JOHN P. WENTWORTH, *Clerk pro tem.*

Boston, Mass., January 10, 1916. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at Myers Hall, Tremont Temple. Chairman Stephen DeM. Gage called the meeting to order at 8.00 o'clock P.M. and introduced the speaker of the evening, Dr. Edward Bartow, director State Water Survey of Illinois. Dr. Bartow gave a very interesting talk, illustrated by lantern slides, on "Activated Sludge."

The subject was discussed by Messrs. H. W. Clark, R. S. Weston, J. H. Gregory, A. L. Fales and H. P. Eddy.

The attendance was 65. Meeting adjourned at 10.15 P.M.

John P. Wentworth, *Clerk pro tem.*

Boston, Mass., February 2, 1916. — A meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in Gilbert Hall, Tremont Temple, at 7.30 o'clock.

A cafeteria supper was served at 6.15 o'clock, to 32 members and guests.

The chairman appointed the following members to serve as a Nominating Committee to report nominations for officers at the annual meeting: Messrs. Almon L. Fales, George C. Whipple and Edward Wright, Jr.

The speaker of the evening was Mr. W. J. Sherman, consulting engineer, of Toledo, Ohio. "The Reconstruction of the Cambridge, Ohio, Water Works" was described by Mr. Sherman in a most interesting manner. Lantern slides were used to show details of the construction.

A rising vote of thanks was tendered Mr. Sherman for his courtesy in coming to Boston to address the Section.

There were 38 present, a very small attendance, due to the severity of the snowstorm, which prevented out-of-town members from attending.

Meeting adjourned at 9.05 o'clock.

Frank A. Marston, *Clerk.*

## APPLICATIONS FOR MEMBERSHIP.

[March 2, 1916.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Appleton, Thomas Allen, Beverly, Mass. (Age 40, b. Beverly, Mass.) Educated in public schools and by private tutor. From Nov., 1892, to March, 1905, with B. & M. R. R., engineering department; from April to Oct., 1906, with N. Y. C. & H. R. R. R.; from Feb., 1906, to date, in private practice in Salem, Mass.; has been town engineer of Marblehead, and was town engineer of Danvers for four years; member of American Society of Civil Engineers. Refers to R. C. Allen, C. A. Fritz, T. P. Perkins, G. F. Temple and H. L. Whitney.

Chase, Guy Herbert, Fitchburg, Mass. (Age 47, b. Lowell, Mass.) Educated in public schools. Experience includes five years in engineering offices in Lowell and Boston, Mass.; nine years with N. Y. C. R. R., W. S. R. R. and R. W. & O. R. R.; five years with Massachusetts Harbor & Land Comm. and Wachusett Met. State Res. Comm.; and eight years in private practice, firm of Parker, Bateman & Chase, of which firm he is still a member; is now commissioner of streets and engineering in Fitchburg. Refers to F. W. Bateman, H. P. Eddy, J. D. Savage and C. W. Sherman.

Ellsworth, Samuel Morrison, Braintree, Mass. (Age 21, b. Braintree, Mass.) Student at Mass. Inst. of Technology, class of 1916, sanitary engineering course. Refers to C. F. Allen, G. L. Hosmer, J. W. Howard, L. J. Johnson and A. G. Robbins.

Gulesian, Selden John, Revere, Mass. (Age 28, b. Marash, Turkey.)

Graduate of Mechanic Arts High School, Boston, 1907; student at Lowell Inst., winters of 1907–1909, mechanical engineering course; in 1912, completed course in steel and concrete design at Franklin Union. From 1907 to 1908, tracer on drawings with Ambursen Hydraulic Construction Co.; during summer of 1908, with Whitman & Howard Co., civil engineers; from 1909 to 1913, with H. P. Converse & Co., engineers and contractors, first as clerk, later as draftsman, estimator and designer; during 1913, held temporary positions as follows: with N. E. Gas & Coke Co., as assistant to Mr. James Taber, civil engineer for the company; as structural steel detailer with Whidden, Beckman Co., engineers and contractors, Boston; and with L. M. Ham & Co., iron and steel workers, as detailer, assistant estimator and outside inspector; in spring of 1914, established National Iron Works, Boston, of which he is owner, manager, estimator and draftsman. Refers to E. P. Bliss, H. N. Cheney, Channing Howard, W. S. Johnson and D. S. Reynolds.

Lothrop, Ernest Elwell, Fitchburg, Mass. (Age 35, b. Cohasset, Mass.) From April, 1901, to 1905, with Whitman & Howard Co., Boston; from 1905 to 1906, with French & Bryant, Brookline; from April, 1906, to May, 1910, with Charles River Basin Comm., first as rodman, finally as assistant engineer; during 1910, in charge of construction of small reservoir at New Britain, Conn.; from April, 1911, to 1915, with Sewage Disposal Commission of Fitchburg, and in 1913 and 1914 had full charge of new disposal plant; during 1915, city engineer of Fitchburg, and is now principal assistant engineer to commissioner of streets and engineering of that city. Refers to W. N. Charles, H. P. Eddy, J. N. Ferguson, J. L. Howard, F. A. Marston, H. A. Miller and C. W. Sherman.

Scully, John T., Brighton, Mass. (Age 37, b. Cambridge, Mass.) Student for three years at Mass. Inst. of Technology, civil engineering course, class of 1901. Since 1901, superintendent, estimator and president of John T. Scully Foundation Co., Cambridge; is also president of Wellesley Gravel Co. Refers to J. E. Carty, C. H. Gannett, C. R. Gow and J. F. Monaghan.

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## LIST OF MEMBERS.

ADDITIONS.

| | |
|---|---|
| Babbitt, John H. | 20 Warland St., Cambridge, Mass. |
| Davis, Thomas C. | 15 Oak Terrace, Newton Highlands, Mass. |
| Hunter, Robert C. | 1020 Fellsway, Malden, Mass. |
| Kleinert, Albert E., Jr. | 108 St. James Ave., Boston, Mass. |
| Maynard, Forrest J. | 23 Irving St., Watertown, Mass. |
| McSweeney, Thomas F. | Framingham, Mass. |
| Parker, Charles F. | Woonsocket, R. I. |
| Smith, William H. | 65 Dartmouth Ave., East Dedham, Mass. |
| Snow, Leslie W. | Care Ames Plow Co., Framingham, Mass. |
| Waite, Edward B. | Millbury, Mass. |

CHANGES OF ADDRESS.

Allardice, James P. . . . . 91 Barnaby St., Fall River, Mass.
Allbright, Edwin F. . . . . 584 Columbia Road, Dorchester, Mass.
Allen, C. Frank . . . . . 88 Montview St., West Roxbury, Mass.
Allen, Leslie H. . . . . 27 School St., Boston, Mass.
Baker, Lloyd E. . . . . City Engineer's Office, Providence, R. I.
Balch, Wm. H. . . . . 46 Green St., Hudson, Mass.
Barnes, Arthur B. . . . . 664 Pearce St., Fall River, Mass.
Cashman, John M. . . . . 137 Irving St., Watertown, Mass.
Clukas, George M. . . . . 161 Devonshire St., Boston, Mass.
Curtis, Allen . . . . . 8 Liberty St., Gloucester, Mass.
Dean, Arthur W. . . . . Room 212, State House, Boston, Mass.
Dolliver, Henry F. . . . . 808 Main St., Westbrook, Me.
Drake, Henry P. . . . . Box 185, Harrisburg, Pa.
Ellis, John W. . . . . Turk's Head Bldg., Providence, and Woonsocket, R. I.
Ellis, Lester F. . . . . 36 Adams St., Winter Hill, Mass.
Emerson, Ralph W. . . . . 90 North St., Pittsfield, Mass.
Fielding, Wm J., care Harbor and Land Comm., State House, Boston, Mass.
Ford, Walter A. . . . . 6 Vesta Road, Dorchester Centre, Mass.
Garrod, J. Arthur . . . . . 35 Powder House Terrace, W. Somerville, Mass.
Hall, Charles L. . . . . Care Standard Oil Co., Shanghai, China
Hammond, Wilberforce B. . . . . 79 Milk St., Boston, Mass.
Harris, Gilbert M. . . . . 319 Huntington Ave., Suite 4, Boston, Mass.
Hayward, Edwin D. . . . . 643 East Seminary St., Greencastle, Ind.
Hazelton, Charles W. . . . . Montague City, Mass.
Herrick, Henry A. . . . . Care Montana Power Co., Butte, Mont.
Holway, Wm. R. . . . . Kent, R. I.
Hunter, Harry G. . . . . Pike Hill Copper Mines, Corinth, Vt.
Jerome, Frank J. . . . . 435 Palmwood Ave., Toledo, Ohio
McCurdy, Harry S. R. . . . . Miami Conservancy District, Dayton, Ohio
Negus, Arthur I. . . . . 147 Milk St., Boston, Mass.
Parker, Charles H. . . . . 1056 Beacon St., Brookline, Mass.
Pinkham, Millard B. . . . . 55 Hanson Pl., Brooklyn, N. Y.
Preble, J. Jarvis . . . . . 80 Howard St., Waltham, Mass.
Rew, Morse W. . . . . Rapid Transit Comm., Cincinnati, Ohio
Richardson, Lyle M. . . . . 515 Dixwell Ave., New Haven, Conn.
Routenberg, Henry W. . . . . P. O. Box 24, Richardson Park, Del.
Sargent, Ezekiel C. . . . . 149 Putnam St., Quincy, Mass.
Small, Gilbert . . . . . Cottage St., Belmont, Mass.
Souther, Theodore W. . . . . 516 Audubon Road, Boston, Mass.
Stevens, George M. . . . . 228 Southampton St., Boston, Mass.
Storrs, Harry A. . . . . Box 352, Tucson, Ariz.
Treadwell, Edw. D. . . . . 55 Marshall Pl., Webster Groves, Mo.
Walker, Phillip B. . . . . 91 Bradford St., Needham, Mass.
Whitney, Russell H. . . . . 56 Sea St., North Weymouth, Mass.

CHANGES OF ADDRESS — CONTINUED.

Winslow, Frederick I. . . . . . . . . . . . . . . 66 Bloomfield St., Dorchester, Mass.

DEATH.

Gerrish, John H. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . February 7, 1916

## EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### Men Available.

246. Age 35. High school education, supplemented by evening courses, etc. Has had five years' experience on railroad work, five years on municipal work, and six years on general engineering work, including Panama Canal, international boundary, reclamation, etc. Desires position as engineering assistant. Minimum salary desired, $100 per month.

289. Age 29. Graduate of Middlebury College, Vt. Has had three years' experience as transitman, draftsman and levelman. Desires position as draftsman and transitman with civil engineer. Salary desired, $12 to $18 per week.

342. Age 28. Graduate of Dartmouth College, with degree of B.S., 1909; senior year in Thayer School of Civil Engineering. Has had about six years' experience as rodman, instrumentman, chief of party, draftsman and assistant engineer on dam construction, boundary surveys, harbor improvements and construction of sewage filtration beds. Desires position as assistant engineer or chief of party upon water supply, sewage disposal, general construction or general surveying work. Salary desired, $125 per month.

348. Age 44. Received technical education from home study and experience in engineering offices. Has had about eight years' experience, including computations, estimates and drafting for water supply and sewerage systems; also design of reinforced concrete structures, such as pumping stations, Imhoff tanks, etc. Desires position as assistant engineer in some consulting, hydraulic, sanitary, or construction engineer's office. Salary desired, $125 per month.

349. Age 35. Received technical education chiefly from correspondence school courses and Franklin Union; has passed the Massachusetts civil service examination for civil engineers, Grade C. Has had fifteen years' experience, including five years with private firm on general engineering and ten years on construction work, the latter consisting mainly of dam, sewer and reservoir construction; served for one year as city engineer of Massachusetts city having population of 37 000. Desires position as engineer in charge of construction. Salary desired, $200 per month in temporary position, or $180 per month in permanent position with chance to advance.

350. Age 24. Graduate of Harvard College, 1914, with degree of S.B. Has had about one and one-half years' experience, including one year as transitman with city engineer and five months as recorder with engineering firm. Desires position as transitman. Salary desired, $20 per week.

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## LIBRARY NOTES.

### Book Reviews.

**Examples in Alternating Currents, Vol. 1.** By F. E. Austin. Hanover, N. H., 1915. Pp. 223, 76 illustrations. Price, $2.40.

*Reviewed by Thomas E. Penard.*

The work is an excellent reference book for students and teachers who are interested in the theory of alternating currents. The mathematical principles are amply illustrated by carefully worked-out problems.

The work covers: Usual notation, — those portions of trigonometry which are applicable to alternating current work; brief rules for differentiation and integration with special reference to types occurring in alternating currents; an introduction to alternating currents with special reference to wave forms, average and effective values, form factors for various waves, a treatment of non-sinusoidal waves, etc.

The author continues with a clear treatment of the subject of inductance and capacity, devoting nearly one half the volume to a discussion of these essential elements, and richly illustrating the principles by carefully chosen problems. Nine pages at the end are devoted to tables of special usefulness in alternating current work.

On page 7 there is a typographical error, giving the value of a Radian as 50.295799 instead of 57.295799. In view of the general excellence of this little volume, it is to be hoped that the numerical work is otherwise free from such errors, and we are looking forward with interest to the appearance of the second volume, which is expected to be ready in the early fall of this year.

**How to Make Low-Pressure Transformers.** By F. E. Austin. Hanover, N. H. Second edition. Price, $0.40.

*Reviewed by Thomas E. Penard.*

This little volume gives working directions for making small transformers of from 100 to 400 watts capacity, for connection to 110-volt, 60-cycle circuits, such as are used for electric bells, spark coils, gas engine ignition, etc.

The treatment is simple and the working directions complete. There are several illustrations. Any one of ordinary ability following the directions can construct these small transformers.

**Directions for Designing, Making and Operating High-Pressure Transformers.** By F. E. Austin. Price, $0.65.

*Reviewed by Thomas E. Penard.*

This little volume gives directions for the design of small step-up transformers giving 20 000 volts for use in connection with wireless telegraphs, telephones, etc. Theory is introduced wherever necessary, and useful tables are included. The mathematics are simple and well within the grasp of the average student.

## Recent Additions to the Library.

**U. S. Government Reports.**

Recent Alunite Developments near Marysvale and Beaver, Utah. G. F. Loughlin.

Annual Report of Bureau of Civil Service to Governor-General of Philippine Islands for 1914.

Annual Report of Chief of Engineers of United States Army for 1915. 3 vols.

Annual Report of Director of Geological Survey for 1914–15.

Annual Report on Statistics of Railways for 1913–14.

Aztec Gold Mine, Baldy, New Mexico. Willis T. Lee.

Cassiterite in San Diego County, California. Waldemar T. Schaller.

Production of Coal in 1914. C. E. Lesher.

Copper in 1914. B. S. Butler.

Reconnaissance of Cottonwood-American Fork Mining Region, Utah. B. S. Butler and G. F. Loughlin.

Field Apparatus for Determining Ash in Coal. C. E. Lesher.

Geology and Coal Resources of Northern Teton County, Montana. Eugene Stebinger.

Notes on Fine Gold of Snake River, Idaho. J. M. Hill.

Gold, Silver, Copper, Lead and Zinc in Arizona in 1914. V. C. Heikes.

Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1914. C. N. Gerry.

Gold, Silver, Copper, Lead and Zinc in Montana in 1914. V. C. Heikes.

Heat Transmission through Boiler Tubes. Henry Kreisinger and J. F. Barkley.

Production of Iron Ore, Pig Iron and Steel in 1914. Ernest F. Burchard.

Lead in 1914. C. E. Siebenthal.

Production of Metals and Ores in 1913 and 1914. J. P. Dunlop.

Production of Natural Gas in 1914. John D. Northrop.

Natural Gas Resources of Parts of North Texas. Eugene Wesley Shaw, George Charlton Matson and Carroll H. Wegemann.

Petroleum in 1914. John D. Northrop.

Public Interest in Mineral Resources. George Otis Smith.

Summary of Railway Returns for Fiscal Year Ending June 30, 1915.

Water-Supply Papers 351, 371, 400-A.

Origin of Zinc and Lead Deposits of Joplin Region, Missouri, Kansas and Oklahoma. C. E. Siebenthal.

**County Reports.**

Essex County, Mass. Engineer's Report for 1915.

**Municipal Reports.**

Boston, Mass. Annual Report of Public Works Department for 1914.

Boston, Mass. Annual Report of Transit Commission for 1915.

Boston, Mass. Digest of Health Laws, 1904. Gift of F. I. Winslow.

Melrose, Mass. Annual Report of Park Commissioners for 1915.

New Bedford, Mass. Annual Report of Water Board for 1915.

New York, N. Y. Contract 170, Board of Water Supply: Copper Lining in Portion of City Tunnel of Catskill Aqueduct.

New York, N. Y. Annual Report of Department of Water Supply, Gas and Electricity for 1914.

Reading, Pa. Annual Report of Bureau of Water for 1913–14.

**Miscellaneous.**

American Handbook for Electrical Engineers. Harold Pender.

American Wood Preservers' Association: Quantity of Wood Preservatives Consumed and Amount of Wood Treated in United States in 1914. Clark W. Gould.

Architects' and Builders' Pocket-Book. 16th ed. Frank E. Kidder.

Canada, Department of Mines: Petroleum and Natural Gas Resources of Canada. Vol. II. Frederick G. Clapp and others; Summary Report of Mines Branch for 1914.

Clean Water and How to Get It. 2d ed. Allen Hazen.

George Ward Blodgett: a Memoir. Henry Ayling Phillips. Gift of Class of 1873, Mass. Inst. of Technology.

Institution of Civil Engineers (London): Minutes of Proceedings. Vol. CC.

International Congress on Hygiene and Demography, 1912: Transactions. 9 vols. Gift of William F. Morse.

International Engineering Congress, 1915: Transactions, Mechanical Engineering.

Alexander Milburn Co.: Milburn Light.

National Board of Fire Underwriters: Regulations Recommended for Storage and Handling of Nitro-Cellulose Motion Picture Films, 1915; Regulations Recommended for Installation of Vaults, 1916.

Reinforced Concrete Construction. Vol. III. George A. Hool.

Principles of Reinforced Concrete Construction. F. E. Turneaure and E. R. Maurer.

River Discharge. John Clayton Hoyt and Nathan Clifford Grover.

Practical Methods of Sewage Disposal. Henry N. Ogden and H. Burdett Cleveland.

Steam-Boiler Economy. William Kent.

Design of Steam Boilers and Pressure Vessels. George B. Haven and George W. Swett.

Structural Engineers' Handbook. Milo S. Ketchum.

Theory of Structures. Charles M. Spofford.

Examples in Alternating Currents. Vol. I.

Directions for Designing, Making and Operating High-Pressure Transformers.

How to Make Low-Pressure Transformers.

Above three items gift of author, F. E. Austin, and are reviewed in this issue.

Water Purification Plants and Their Operation. Milton F. Stein.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the first of each month.)

**Commonwealth of Massachusetts.**—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.*

*Bellevue Reservoir.* — The construction of the masonry tower on Bellevue Hill in West Roxbury is completed with the exception of the tiling on the roof, work on which is in progress during favorable weather.

*Sudbury Power Plant.* — The work of installing the hydro-electric machinery at the Sudbury Dam in Southboro is in progress.

*Sewerage Works.* — Work is in progress on Section 19, Malden River Siphon, under compressed air; Section 104, Wellesley extension sewer; and the Deer Island Outfall Sewer Extension.

The new work contemplated includes Sections 98 to 102 of Wellesley extension.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Charles River Reservation.* — The work of building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown, is in progress. A. G. Tomasello, contractor.

Plans are being prepared for bridge over the Charles River at Commonwealth Ave., between Newton and Weston, and bids will be asked for the work before spring.

Work of excavating channel of Charles River from Elm St. to Bleachery Dam, Waltham, is in progress. John R. Burke, contractor.

*Furnace Brook Parkway.* — Work of construction of parkway extension from Quincy Shore Reservation to Hancock St. is in progress. John Cashman & Sons Co., contractor.

Work of building reinforced concrete girder bridge across Blacks Creek, for Furnace Brook Parkway Extension, is in progress. Hugh Nawn Contracting Co., contractor.

*Mystic Valley Parkway.* — Work of excavating the channel of Aberjona River from Boston & Maine Railroad Bridge to Waterfield St., Winchester, is in progress. Coleman Brothers, contractors.

*Old Colony Parkway.* — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old Neponset Bridge.

Directors of the Port of Boston. — *Reclamation of State Flats at East Boston.* — During the latter part of November, 1915, the Directors awarded to the Bay State Dredging & Contracting Co. the first of three contracts in the reclamation of state flats adjacent to Jeffries Point, East Boston.

Substantial progress has been made under this contract, which involves the construction of a timber retaining structure 2 200 ft. in length. About 60 000 cu. yds. of filling material have been placed along the line of the structure, and a considerable amount of pile driving has been done by the William L. Miller Co.

Bids were opened by the Directors on March 6, 1916, for the excavation of 450 000 cu. yds. of material in the removal of a large shoal off the Mystic Wharf of the B. & M. R. R. Co. The removal of this shoal will greatly facilitate handling of shipping in Mystic River, and the material removed will be deposited at East Boston and there used for filling the state flats. On the same date the Directors opened bids for depositing by the hydraulic process 1 000 000 cu. yds. of material. This amount of material will fill an area of 35 acres to 16 ft. above mean low water. If contracts are awarded, it is expected that this reclamation will be accomplished during the present season.

*Removal of Shoals at Weymouth Fore River.* — A contract was made with the Bay State Dredging & Contracting Co. for furnishing plant to drag down shoals in Weymouth Fore River in order to facilitate the removal of the U. S. Battleship *Nevada* from the yards of the Fore River Shipbuilding Plant.

These shoals were removed to a depth of 19 ft. below low water in six working days.

*Railroad Track at South Boston.* — Plans are in preparation for the extension of two industrial railway tracks from the freight yard of the N. Y., N. H. & H. R. R. Co. to the lands of the Commonwealth south of Summer St.

By the installation of these tracks state lands valued at about $1 000 000 will be made available for industrial and warehouse purposes, with rail connection to the system of the N. Y., N. H. & H. R. R. Co.

*Sewer in Fargo St., South Boston.* — A sewer is being installed in Fargo St. by James H. Ferguson. This sewer will extend from D St. to a connection with the sewer of the City of Boston at C St.

*Street Railway Tracks to Fish Pier.* — With the coöperation of the Boston Elevated Railway Co., plans and specifications are being prepared for the installation of a double-track street railway from Summer St. along the viaduct and ramp to the Fish Pier at South Boston.

*Extension of Northern Ave. to Dry Dock.* — The Charles R. Gow Co. has completed a series of wash borings to determine the character of foundation along the line of Northern Ave. from the Fish Pier to the Dry-Dock, and the Directors have completed plans and specifications for this extension of Northern Ave. by the construction of a timber bulkhead and the utilization of cinders, ashes and material from cellar excavations at South Boston for the filling material.

*Removal of Hamburg-American Steamships.* — The interned Hamburg-American steamships *Amerika* and *Cincinnati* have been removed from Commonwealth Pier 5 to new berths at East Boston. By the removal of these steamships the westerly side of the terminal is made available for the docking of freight steamships with cargo.

*Dry-Dock.* — At the dry-dock the Holbrook, Cabot & Rollins Corporation has continued to assemble plant and to lay standard gage railroad tracks in preparation for construction work.

A large force of men are cutting dimension stone at the quarries of the Rockport Granite Co., and considerable granite has been delivered at the site of the dry-dock.

Excavation of earth overlying the rock at the dry-dock site is being done by the large clam-shell dredge of the Morris & Cumings Dredging Co. with a 10 cu. yd. bucket. About 250 000 cu. yds. of material have been removed.

Cofferdam construction across the entrance to the dry-dock has been started at each end. This dam will be similar to that constructed by the Holbrook, Cabot & Rollins Corporation around the lock at the Charles River Dam, and consists of two lines of timber sheeting driven well into the clay bottom. These lines of sheeting are supported by the customary pile and timber supports with earth filling within to 17 ft. above low water and on either side to high water.

**Boston Transit Commission.** — *Dorchester Tunnel.* — Descriptions of Sections D, E, G and H were printed in the JOURNAL in October and December, 1915.

Section D includes the station under Dewey Square, to be known as South Station Under. The interior finish on the walls consists of terrazzo and mosaic tile, above which is white Portland cement plaster, which is nearing completion. Escalators of the cleat type are being installed, and shelters of polished granite and concrete are being erected over the entrances and exits of the station.

In Section E both shields are under the channel, the one for the easterly tunnel being within about 700 ft. and the one for the westerly tunnel within about 1 300 ft. of the northerly end of the section, where they will meet the completed tunnel at the easterly end of Section D under Summer St. About two thirds of the construction of Section E is done.

On Section G, construction by the tunnel method of the 3 ft. by 5 ft. and 4 ft. 9 in. by 5 ft. 6 in. intercepting sewer in Dorchester Ave. is in progress.

The construction of the pump well at B St. and the excavation for the incline and for the tunnel by open cut between West Fourth and B streets in Dorchester Ave. is in progress. Tongued and grooved sheeting is being driven.

The construction of Section H has been substantially completed with the exception of a pump well at D St. and a ventilating chamber and emergency exit near Woodward St.

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Seventeen submarines for United States Navy.
One submarine for Spanish Navy.
Three oil steamers for the Texas Co.
Four freight steamers for the Luckenbach Co., Inc.
Three molasses steamers for Cuba Distilling Co.
One oil steamer for Argentine Republic.

Vol. III APRIL, 1916 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

FRIDAY, APRIL 21, 1916,

at 8 o'clock P.M., in the Assembly Room of the Engineers' Club, Commonwealth Avenue, corner of Arlington Street, Boston.

The Board of Government will submit a report, prepared by a committee of its members, in relation to Permanent Bench Marks about Boston and Vicinity, and will recommend that the suggestions made in the report be adopted by the Society. The report is printed in this number of the JOURNAL.

Dr. Alexander C. Humphreys, president of the Stevens Institute of Technology and past president of the American Society of Mechanical Engineers, will read a paper entitled, "Reform and Regulation." The paper will have to do with reform in the regulation of public-service utilities.

The Boston Section of the American Institute of Electrical Engineers and the local members of the American Society of Mechanical Engineers have been invited to join in the meeting.

S. E. TINKHAM, *Secretary.*

## PAPERS IN THIS NUMBER.

Address at the Annual Meeting, Charles R. Gow.
"Spillways of the Panama Canal," Edward C. Sherman.
"Latest Method of Sewage Disposal," Edward Bartow.
"Service for the Society," Edmund M. Blake.

## Current Discussion.

| Paper. | Author. | Published. | Discussion Closes. |
| --- | --- | --- | --- |
| "Power Estimates." | D. M. Wood. | March. | May 10. |



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

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# REPORT OF COMMITTEE ON PERMANENT BENCH MARKS.

Lawrence, Mass., February 24, 1916.

To the Board of Government,
Boston Society of Civil Engineers, Boston, Mass.
Chas. R. Gow, *President.*

The Committee appointed by the President of the Boston Society of Civil Engineers in relation to Permanent Bench Marks about Boston and vicinity herewith present the following report.

The subject was brought to the attention of the Society through a letter signed by geologists connected with Tufts, Harvard and Technology, dated May 24, 1915, asking for coöperation of the Boston Society of Civil Engineers in relation to establishing permanent bench marks and tide gage in Boston and vicinity. The object was to make a more definite study of the harbor and coast and to determine the effect of the changes which follow such progress with the development of a great city, such as dredging channels, filling flats, building masonry walls, docks, etc.

Investigation in the past by Mr. John R. Freeman, civil engineer, has shown by his report on the Charles River Dam, dated 1903, that a gradual subsidence of the coast about Boston is in progress at the rate of about a foot in one hundred years, and, although other authorities have differed somewhat regarding his opinion, it is considered of great importance that more definite information should be obtained bearing on this subject.

The various correspondence relating to the subject is attached and made a part of this report, and is included in the following list with dates:

May 24, 1915, Professors of Geology to S. E. Tinkham.

June 7, 1915, Prof. Alfred C. Lane to S. E. Tinkham.

*July 1, 1915, J. R. Freeman to R. A. Hale.

December 28, 1915, R. A. Hale to Port Directors, J. L. Howard.

December 29, 1915, R. A. Hale to U. S. Coast and Geodetic Survey.

*December 30, 1915, R. E. Barrett (Port Directors) to Boston Society of Civil Engineers.

January 3, 1916, R. A. Hale to Robert E. Barrett (Port Directors).

*January 10, 1916, U. S. Coast and Geodetic Survey to R. A. Hale.

January 14, 1916, R. A. Hale to U. S. Coast and Geodetic Survey (Faris).

The committee had interviews with various public boards, and found a great willingness to coöperate with them in every possible way. It was apparent, however, that with the large field for investigation it would hardly be possible for one board to carry out the general plan, but that a coöperation must be had with other boards. Your committee wrote to the U. S. Coast and Geodetic Survey for information and suggestions, and received a most courteous reply offering assistance by having a precise leveling party run lines of levels connecting various benches when a comprehensive plan was developed.

The Port Directors have stated that they would set a long rod in the solid ledge during the process of construction of the dry-dock which would be extended to the top of the wall where it would be accessible. A self-recording tide gage is now being established in South Boston, which will be carefully observed.

The Metropolitan Water Board has accurate benches established along the lines of its conduits, which would eventually be connected as part of a uniform system, and a coöperation is assured on their part, as far as practicable.

The City of Boston would be interested through its Highway Departments, and would doubtless coöperate through the engineers of the departments.

The various suggestions are made, as will be seen in the correspondence attached and in which further details are discussed. Your committee would make the following suggestions as a basis of organization: That a committee should be created, consisting of a representative of the Port Directors, a representative of the Metropolitan Water and Sewerage Board, a representative of the City of Boston, a representative of the Boston Society of Civil Engineers, and a representative of the geologists in the vicinity of Boston. This committee could agree on a definite plan of operation, confer with the U. S. Coast and Geodetic Survey, who have offered their services, and whatever is carried out should be a part of a well-defined plan embracing a system of permanent benches and tide gages that would give more definite information than is at present attainable. It doubtless would entail considerable expense to carry out a complete scheme in detail at once, but if a general scheme could be definitely outlined by such a committee, portions of it could be accomplished as opportunity offered and made a part of a final plan with the coöperation of all boards.

Respectfully submitted,

RICHARD A. HALE.
FRANK O. WHITNEY.

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* Printed herewith.

PROVIDENCE, R. I., July 1, 1915.

RICHARD A. HALE, CIVIL ENGINEER,
Care of THE ESSEX COMPANY,
LAWRENCE, MASS.

*Dear Mr. Hale:*

BOSTON BENCH MARKS.

I am much interested in your letter of June 30 and in the recommendations of the Committee on Bench Marks, composed of Shimer, Lingren, Crosby, Lahee and Warren, dated May 24, 1915, at Tufts College and addressed to S. E. Tinkham, Secretary.

My personal opinion is that this matter of bench marks is a very important one and should receive attention.

I believe the work could probably best be carried on by the committee seeking to meet with representatives of the Boston Board of Public Works and of the Metropolitan Water and Sewerage Board, possibly also the Metropolitan Park Commission and the Port Directors, in order to have these, the principal boards of public works bordering on the harbor, coöperate in the precise leveling and in the independent checking and in order that each should in the future recognize a sense of proprietary interest and responsibility in this matter of standard bench marks.

As to the bench marks themselves, my own idea is that there should be more than the three recommended by Professor Woodbridge. I would want more time than I have this morning before making any recommendation in detail as to just where the different bench marks should be located, but in a general way my first thought would be that this location should be somewhat as follows:

No. 1. As near as practicable on solid ledge within public property and easy of access to any engineer in years to come, a reference bench for the tide gages at the Boston Navy Yard and as close as practicable thereto, so as to encourage frequent comparison.

No. 2. A plate could be cut into the side of the Bunker Hill Monument at a point convenient for transfer into the central shaft, with a secondary bench in one or more of the topmost window sills for trigonometric leveling.

No. 3. On the interior of the shaft structure of the East Boston Tunnel at Atlantic Avenue, at a point that can be reached conveniently for precise vertical measurement to a reference point at the bottom of the tunnel and another to the outside of the building.

No. 4. On the Commonwealth Pier at South Boston. This preferably to have its stability assured by a wash boring in a four-inch pipe down to bed-rock, the four-inch pipe being sealed into bed-rock and the hole then continued, say, three inches in diameter for, say, ten feet into the rock, with a steel rod with screw couplings and a jagged end bedded in cement into the ledge by first blowing out the hole, preferably with compressed air, and then filling it with soft cement grout, into which the jagged end of the rod should be forced, thereby making sure of the grip between the rod and the ledge. The space between the steel rod and the casting pipe should then be filled with coal tar tempered with lime.

If a bar of Invar steel nickel alloy could be procured, it might be made a little smaller, but the cost of this nickel alloy should not be beyond the means of the Commonwealth, and of course the top of the rod would be given appropriate finish and treatment for its preservation. This would naturally serve as the standard bench for South Boston levels.

Continuing around the harbor, a precise bench should be established at Cohasset and transfers made with all possible precision to the Minot's Ledge Lighthouse, with a standard bench and connections for a tide gage at the base.

Similarly, both from Point Allerton and from Point Shirley, transfers should be made to Boston Light, with appropriate connections for a tide gage to be maintained now and then for a full year series.

Incidental to this transfer to Boston Light and the checking across, substandard benches should be left with deep foundations and appropriate precautions against settlement and temperature changes in the masonry at both Point Allerton and Point Shirley or Deer Island.

For the interest of the Metropolitan Water and Sewerage Commission, this line of standard benches might very appropriately be transferred inland and standards left on the solid rock and with elaborate covers and housings at various points within the public reservations.

Very truly yours,

(Signed) JOHN R. FREEMAN.

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DIRECTORS OF PORT OF BOSTON.

BOSTON, December 30, 1915.

TO THE BOARD OF GOVERNORS,
BOSTON SOCIETY OF CIVIL ENGINEERS:

*Gentlemen*, — On December 28, 1915, a letter was received from Mr. Richard A. Hale, representing the committee appointed by the Boston Society of Civil Engineers to investigate and report upon the matter of establishing permanent benches in and around Boston. Accompanying the letter was a communication signed by the consulting geologists of Boston, urging the establishment of a tide-gage station and permanent benches, by public authority, set into granite in the vicinity of Boston Harbor.

A few months ago the Directors of the Port of Boston approved of the establishing by their engineering department of a permanent tide-gage station at Commonwealth Pier No. 5, South Boston. A recording tide gage has been constructed and delivered, but has not as yet been installed.

The establishment of this tide-gage station was intended for the public good, and for the purpose of determining the plane of mean low water, and its installation will give to the pilots and others interested in the actual depths of water in the Boston Harbor channels positive information at any hour of the day.

During the past few months steamships of considerable draft have left this port, and on August 15, 1915, the *Canopic*, of the White Star Steamship Company, left Commonwealth Pier No. 5 drawing 34 ft. 6 ins. aft, and as the main ship channel in Boston Harbor has a depth of but 35 ft. at mean low water, it is becoming necessary that pilots and others should have definite information as to the elevation of the tide.

The Directors of the Port of Boston desire to coöperate with the Boston Society of Civil Engineers in the establishment of permanent benches and tide-gage station, as suggested by the consulting geologists of Boston, and will welcome any suggestions in regard to the installation of the tide gage purchased by the Directors a few months ago.

A contract has been awarded for the construction of a dry-dock at South Boston. This structure will be constructed of cyclopean concrete masonry on ledge rock, and undoubtedly an opportunity can be given for the establishing of a permanent bench in connection with the construction of this structure, by imbedding a rod in ledge rock, or by any method acceptable to your committee.

I desire to call to your attention in connection with the above that there has existed for many years several systems of levels in and around the harbor of Boston, separate systems being maintained by the City of Boston, the Commonwealth of Massachusetts and the United States Government, and the desirability of establishing a uniform system of levels, recognizing the fact that an increasing amount of subsurface work is being done by various public authorities.

Very truly yours,
(Signed) Robert E. Barrett,
*Acting Chief Engineer.*

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Department of Commerce.
The U. S. Coast and Geodetic Survey,
Washington.

January 10, 1916.

Mr. Richard A. Hale,
*Vice-President,* Boston Society Civil Engineers,
Care of Essex Company, Lawrence, Massachusetts:

*Sir,* — Your letter of December 29, 1915, in regard to the question of determining the elevations of some substantial bench marks in the vicinity of Boston, has been received, together with copies of certain other letters relating to the same subject.

In reply I wish to state that the Coast and Geodetic Survey is very much interested in the question of the stability of our coasts, and, in consequence, at each of our permanent tide-gages we try to establish a number of bench marks which will be as free as practicable from disturbance by the operations of man or by the superficial settling of the ground.

The plan outlined in your letter and in those accompanying it seems to be a rather elaborate one. It is, however, probably a good one to follow.

It is probable that we can coöperate in carrying it out. I would suggest that the local organizations establish the bench marks, and that one of our observers run the line or lines of precise leveling between them. I can give you a definite reply after the parties interested come to a conclusion as to the amount of leveling to be done. We would furnish the instruments and the observer, free of all cost to the local organizations concerned. It is suggested that some decision be reached shortly in regard to the matter, in order that one of our officers, who will be running levels in New England during the coming summer, may make the necessary leveling in Boston on his way to the field, if we can coöperate with you.

The Coast and Geodetic Survey is not carrying on tidal observations in the vicinity of Boston at the present time, although a series of about thirty years' duration was made at the tidal station at the Charlestown Navy Yard. If the gage is now in operation at that place, the observations are probably being made by the naval authorities or by the officers of the army engineer corps. It is our intention to resume our automatic tide-gage in the vicinity of Boston as soon as funds are available for the purpose. At present the appropriation for tidal work makes it impossible to maintain the Charlestown gage.

Many kinds of bench marks are in use, and some are very satisfactory. I would suggest that a report entitled, "Precise Leveling in New York City," by Frederick W. Koop, be consulted before bench marks are arranged for in connection with the work in Boston and vicinity. It is believed that a copy may be obtained from the Chief Engineer, Board of Estimate and Apportionment, New York City, or you may have a copy in your library. There is no doubt but that, for the best results, bench marks should be established on bed-rock.

We are using, for nearly all of our bench marks, a copper disk properly inscribed, set into masonry buildings, solid rock or concrete. One of these disks will be mailed to you under separate cover. We find that if a visitor to a bench mark finds out just what it is from the inscription, he is not likely to disturb it. Formerly many of our marks were lost through the curiosity of visitors who destroyed them in search of possible "buried treasure."

We shall await further communications from you in regard to these matters.

Respectfully yours,

(Signed) R. L. Faris,
*Acting Superintendent.*

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## MINUTES OF MEETINGS.

Boston, March 15, 1916. — The sixty-eighth annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, Somerset Street, Boston, at 12.15 o'clock P.M., President Charles R. Gow in the chair.

The reading of the record of the last regular meeting was, by vote, dispensed with and it was approved as printed in the March JOURNAL.

The Secretary reported for the Board of Government that it had elected to membership in the grades named, the following candidates:

Members — Thomas Webster Bean, Charles Henry Breen, Ralph Dutton Hood, George Wallace Lewis, Royal Luther, Dean Peabody, Jr., and Ralph Edward Whitney.

Associates — Francis Bernard Farrell and David R. Howard.

Juniors — Ralph Upton Cross and John Mathes Turner.

The Secretary announced the death of Erasmus Darwin Leavitt, an honorary member of the Society, which occurred on March 11, 1916. By vote the President was requested to appoint a committee to prepare a memoir. The President has appointed as the committee, Charles T. Main and Will J. Sando.

The Secretary read the annual report of the Board of Government, and by vote it was accepted and ordered to be printed in the JOURNAL.

The Treasurer read his annual report and the accompanying report of the Auditors, and by vote they were accepted and ordered to be printed in the JOURNAL.

The Secretary read his annual report, and by vote it was accepted and ordered to be printed in the JOURNAL.

The Librarian read the report of the Committee on the Library, and by vote it was accepted and ordered to be printed in the JOURNAL.

Mr. E. M. Blake presented and read the report of the Committee on Social Activities, and by vote it was accepted and ordered to be printed in the JOURNAL.

The recommendations made in the report of the Committee on the Library were, by vote, referred to the Board of Government, with full powers.

On motion of Past-President Stearns, it was voted to refer to the Board of Government, with full powers, the question of appointing the special committees of the Society.

Mr. F. A. Marston offered the following motion: That the Board of Government be requested to appoint a committee of three members to investigate and report at an early date in regard to arranging for a series of lectures on military engineering.

After a discussion, the following substitute motion, offered by Past-President Eddy, was adopted: That the matter of arranging for a series of lectures on military engineering be referred to the incoming Board of Government, with full powers.

The retiring President, Mr. Charles R. Gow, then delivered the annual address, which is published in this issue of the JOURNAL.

The members then adjourned to the auditorium of the Club to partake of the thirty-fourth annual dinner.

During the dinner, in response to the felicitous calls of the President, short speeches in a happy vein were made by Past-Presidents Eddy and Rollins, and by Mr. Charles H. Eglee. There was also singing of Society songs under the leadership of Mr. Olin, with Mr. Blake at the piano.

At the close of the dinner, business was resumed. The Secretary read the report of the tellers of election, Messrs. Frederic A. Caldwell and N. LeRoy Hammond. In accordance with this report, the President announced that the following officers had been elected:

President — Richard A. Hale.

Vice-President (for two years) — Lewis M. Hastings.

Secretary — S. Everett Tinkham.

Treasurer — Frank O. Whitney.

Directors (for two years) — Arthur W. Dean and Sanford E. Thompson.

The President then presented the President-elect, Mr. Richard A. Hale. Mr. Hale in accepting the office expressed his deep appreciation of the honor conferred upon him and thanked the members most sincerely for their confidence. He promised his best efforts for the coming year to advance the interests of the Society and to promote the success of its meetings.

Past-President Frederic P. Stearns, at the request of the President and in the name of the Society, presented the Desmond FitzGerald Medal for the year 1915 to William S. Johnson, for his paper entitled, "Ground Water Supplies." Mr. Johnson, in accepting the medal, thanked the Society for the honor conferred in the award of the medal to him this year.

At three o'clock the President presented Dr. Charles H. Tyndall, of Mount Vernon, N. Y., who gave a very interesting lecture on "The Wonders of Ether Waves and Radium and Its Mysteries." By means of experimental apparatus he demonstrated the principles of wireless telegraphy, invisible light, inaudible sounds, telepathy, etc. He also illustrated by actual samples of radium many of its mysterious properties and their influence in explaining well-known scientific phenomena.

In the evening the "Smoker" was held in the auditorium, the attendance being 314. Light refreshments were served and an entertainment followed furnished by the White Entertainment Bureau, in which the following talent appeared: Andrew Vissocchi, accordion virtuoso; Charles Bacon Pettes, classic dancer and female impersonator; Herbert A. Clark, humorist; Edwin M. Whitney, king of story-tellers; and Rollo Hudson, accompanist.

S. E. Tinkham, *Secretary.*

## Annual Meeting of the Sanitary Section.

Boston, Mass., March 1, 1916. — The annual meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening at the Engineers' Club.

Dinner was served in the Assembly Hall at six o'clock, to 28 members and guests. At the close of the dinner, addresses were made by Gardiner T. Swarts, M.D., bacteriologist, Rhode Island State Board of Health; and by the Chairman of the Section, Stephen DeM. Gage.

The business meeting was opened by Chairman Gage at 7.40 o'clock. The minutes of the past three meetings were ordered printed in the Journal without being read.

The annual report of the Executive Committee was read by the Clerk.

Voted to accept the report and place it on file.

Voted that the following recommendation of the Executive

Committee be accepted and the matter referred to the Board of Government by the incoming chairman:

That the Board of Government of the Society be requested to consider and if possible take measures to provide for definite quarters where the meetings of the Sanitary Section may be held.

A verbal report for the Committee on Outfall Sewers was given by G. A. Sampson.

Voted that the report be accepted and the committee continued as requested.

A verbal report for the Committee on Inverted Siphons was presented by Wm. S. Johnson, chairman. The committee asked that the Executive Committee appoint a meeting for the presentation of a progress report and for discussion of the subject.

Voted to accept the report and continue the committee as requested.

The report of the Nominating Committee was read by the chairman, Almon L. Fales.

Voted to accept the report, and that Mr. Carpenter be instructed to cast one ballot for the list of officers as suggested by the Nominating Committee.

The ballot having been cast by Mr. Carpenter, the following list of officers were declared elected for the ensuing year:

Chairman — Prof. Frederic Bonnet, Jr.
Vice-Chairman — Edward Wright, Jr.
Clerk — Frank A. Marston.

Additional members of the Executive Committee:

Stephen DeM. Gage.
Alfred O. Doane.
Roy S. Lanphear.

On motion of Wm. S. Johnson, seconded by E. S. Dorr, voted: That a committee, of size and make-up as they deem proper, be appointed by the Executive Committee to consider and report upon the subject of "Sewer Assessments."

The chairman then introduced the speaker of the evening, Stanley H. Osborn, M.D., State District Health Officer for the Berkshire District, Mass., who related his "Eight Months' Experiences in Servia with the American Sanitary Commission."

The talk was profusely illustrated with lantern slides made from photographs taken by the speaker. His varied experiences under trying circumstances were told in a most entertaining manner.

Voted: That the thanks of the Section be extended to Dr. Osborn for his courtesy in addressing the meeting.

The incoming chairman of the Section, Dr. Frederic Bonnet, Jr., was then introduced and assumed charge.

Meeting adjourned at 9.45 o'clock.

There were 65 present at the meeting.

FRANK A. MARSTON, *Clerk.*

## ANNUAL REPORTS.

### ANNUAL REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1915–1916.

BOSTON, MASS., March 15, 1916.

*To the Members of the Boston Society of Civil Engineers:*

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 15, 1916.

The total membership of the Society a year ago was 928, of whom 832 were members, 58 juniors, 3 honorary members, 24 associates, and 11 were members of the Sanitary Section only.

The total loss in membership during the year has been 51, of whom 23 resigned, 14 forfeited membership on account of non-payment of dues and 14 have died.

There has been added to the Society during the year a total of 122 members of all grades; 119 have been elected and completed their membership; 3 have been reinstated, 3 juniors and 2 members of the Sanitary Section have been transferred to the grade of member. Two members have been elected and accepted honorary membership, and the honorary member elected last year has accepted his election. Eight applicants have been elected but have not completed their membership, and there are 19 applications now before the Board for action.

The present membership of the Society consists of 6 honorary members, 875 members, 83 juniors, 26 associates and 9 members of the Sanitary Section only, making a total membership of 999, a net gain during the year of 71 members.

The Board of Government by unanimous vote has elected as honorary members, Past President Desmond FitzGerald and Past President Frederic Pike Stearns.

The loss by death during the year is 14, the largest number in any year of the Society's history. The record is as follows:

Isaac Rich, died March 11, 1915.
Benjamin G. Fogg, died March 14, 1915.
Alexis H. French, died May 3, 1915.
Walter Jenney, died May 3, 1915.
Edmund K. Turner, died May 6, 1915.
Theodore L. Keppler, died May 24, 1915.
Lorenzo G. Moulton, died June 9, 1915.
Ernest P. Whitten, died June 17, 1915.
Dexter Brackett, died August 26, 1915.
J. Herbert Shedd, died November 27, 1915.
Emory A. Ellsworth, died December 8, 1915.
Thomas F. Richardson, died December 26, 1915.
S. Foster Jaques, died January 8, 1916.
John H. Gerrish, died February 7, 1916.

Under authority of By-Law 8, the Board of Government, for reasons which it deems sufficient, has remitted the dues of twenty-three members of the Society.

Eleven meetings have been held during the year, ten regular and one special. The average attendance at the regular and special meetings was 113, the largest being 260 and the smallest 35.

The following papers and addresses have been given:

*March 17, 1915.* — Address of Retiring President Eddy. Address by Mr. Frederick H. Newell, " Engineering and Economic Results Obtained by the United States Reclamation Service." (Illustrated.)

*March 31, 1915.* — Special address by Mr. Edward F. McSweeney, " The Future of the Port of Boston." (Illustrated.)

*April 21, 1915.* — Mr. J. Albert Holmes, " Construction of the Earth Dam at Somerset, Vermont." (Illustrated.)

*May 19, 1915.* — Prof. Albert Sauveur, " The Structure of Iron and Steel." (Illustrated.)

*June 16, 1915.* — Prof. Charles F. Binns, " The Application of Clay Products to Some Engineering Problems." (Illustrated.)

*September 15, 1915.* — Mr. M. J. Lorente, " Some Special Methods of Reinforced Concrete Designs."

*October 20, 1915.* — Mr. Wm. S. Johnson, " The Water Supply of Salem, Mass." (Illustrated.)

*November 17, 1915.* — Mr. Frank C. Shepherd, " The Federal Valuation of the Boston and Maine Railroad."

*December 15, 1915.* — Mr. A. A. Cohill, " The Construction of the Dorchester Tunnels under Fort Point Channel." (Illustrated by lantern slides and motion pictures.)

*January 26, 1916.* — Mr. Wm. R. Farrington, " Sand and Oil Roads and Surfaces."

*February 26, 1916.* — Mr. Edward C. Sherman, " The Spillways of the Panama Canal." (Illustrated.)

The Sanitary Section has held seven meetings with an average attendance of 69. The following papers have been presented at the meetings of the Sanitary Section:

*March 3, 1915.* — " The Sewage Disposal Works at Fitchburg, Mass.," David A. Hartwell.

*November 3, 1915.* — Excursion to Albany Street pumping station, Boston, at 5 o'clock P.M., followed in the evening by a paper, "The South End Sewer System," Edgar S. Dorr.

*November 24, 1915.* — "Mosquito Extermination Work," Harold I. Eaton.

*December 1, 1915.* — "Proposed Improvements of the Quequechan River, Fall River, Mass.," Frederic H. Fay.

*January 5, 1916.* — "Sanitary Work in the United States Army," Maj. James F. Hall, Medical Corps, U. S. A.

*January 10, 1916.* — "Activated Sludge," Dr. Edward Bartow.

*February 2, 1916.* — "The Reconstruction of the Cambridge, Ohio, Water Works," W. J. Sherman.

The Joint Engineering Dinner was held at the Boston City Club on Tuesday, February 8, 1916, under the direction of a committee representing this Society, the Boston Section of the American Institute of Electrical Engineers and the local members of the American Society of Mechanical Engineers, the latter organization taking the more active part in the management this year. The attendance was 384. The meeting was addressed by his Excellency Governor McCall, and others, and proved to be one of the most enjoyable of these annual functions.

On April 29, 1915, the students in the civil engineering courses at Harvard Institute of Technology and Tufts were entertained by the Society at Ford Hall; a few students were also present from Worcester Polytechnic Institute and from the Thayer School at Dartmouth. The attendance was about 264.

The Board of Government has adopted the recommendation of the committee appointed to award the Desmond FitzGerald medal and announces that it will be given this year to William S. Johnson for the paper entitled "Ground Water Supplies," which was published in the JOURNAL of the Society for May, 1915.

The work of rearranging and cataloguing the library has been continued during the year. Two new steel stacks and a periodical rack have been added, as well as other furnishings. For this purpose the Board expended $554.61, which sum has been paid from the special appropriation made from the Permanent Fund in November, 1912. The unexpended balance of this appropriation, amounting to $58.91, has been returned to the Permanent Fund in accordance with By-Law 9.

Under a provision of the will of our late associate, Edmund K. Turner, the Society has received from the executors of his estate the engineering books in his library, numbering 1,105 bound volumes. While some are duplicates of those already in the library, they make a substantial addition to our library, especially in the line of railroad engineering literature. Mr. Turner made a further bequest of the sum of $1 000, the income of which is to be used for library purposes. This bequest has been paid over to the Society and, by vote of the Board, it is to be carried on the Treasurer's book as a separate fund, known as the Edmund K. Turner Fund.

A bequest of $1 000 is made the Society in the will of Past President Alexis H. French, the income of which is to be used for library purposes. This bequest, however, will not be immediately available.

The report of the Editor of the JOURNAL for the calendar year 1915, which is submitted for publication with the reports of the other officers of the Society, shows that a total of 742 pages was printed in the ten issues, with 49 cuts and 5 inserted plates, at a gross cost of $2 726.11. The net cost, after deducting sums received for advertisements, sales of JOURNAL, etc., was $1 185.62, or an average of $118.56 per issue.

This net cost to the Society of the JOURNAL, of a little less than $1 200 per year, shows that the adoption of an independent publication by the Society has resulted to its financial advantage, as the average cost to the Society of the *Journal of the Association of Engineering Societies* was about $2 000 per year, or about $1 850 per year when the net profit derived from the *Bulletin* is considered.

There has been added to the Permanent Fund during the year $1 613.25. The present value of this fund is now $37 475.69, and, with the Edmund K. Turner Fund, makes the total invested funds of the Society $38 475.69, an increase during the year of nearly $3 900.

From the Treasurer's report it appears that the revenue for the year applicable to current expenses has been $9 273.33, while the amount expended has been $8 504.92, leaving an excess of revenue over expenses of $768.41, which, added to balance at the beginning of the year, makes the total cash on hand in the Current Fund $1 194.89.

The Committee on Social Activities, under the direction of its efficient chairman, Edmund M. Blake, has continued the excellent work begun last year, and the informal dinners which have been arranged to immediately precede our regular meetings have been heartily appreciated by the members participating. The report of the committee gives the detail of these most enjoyable gatherings.

The Committee on Papers and Program, Lewis E. Moore, chairman, has provide the speakers and papers for the regular meetings, and the Society is under great obligation to the members of this committee for their most satisfactory service during the past year.

While the Committee on Membership, John E. Carty, chairman, have not deemed it best to conduct as vigorous a campaign for new members as last year, the result of their work is seen in the very substantial addition to our membership.

For the Board of Government,

CHAS. R. GOW, *President.*

## REPORT OF THE TREASURER.

BOSTON, March 1, 1916.

*To the Boston Society of Civil Engineers:*

Your Treasurer presents the following report for the year 1915–16:

Detailed data are contained in the appended tabular statements. Table 1 gives the receipts and expenditures for the year; Table 2, comparative balance sheets; and Table 3, investment of the Permanent Fund.

The revenue applicable to current expenses has been $9 273.33, about $1 100 greater than for the preceding year. The current expenses were $8 504.92. The surplus in the current funds has increased to $1 194.89.

There has been expended from Furnishings Fund $554.61, and the balance of $58.91 has been transferred to the Permanent Fund.

There has been added to the Permanent Fund during the year $2 893.56, including $58.91, the unexpended balance of the Furnishings Fund.

A new fund has been created, to be known as the "Edmund K. Turner" Fund, in accordance with a bequest of $1 000 under the will of our late fellow-member, Edmund K. Turner.

Respectfully submitted,

F. O. WHITNEY, *Treasurer.*

TABLE 1. — RECEIPTS AND EXPENDITURES.

CURRENT FUND.

*Receipts.*

| | |
|---|---|
| Balance from March, 1915 | $426.48 |
| Members' Dues | 7 550.83 |
| Advertisements | 1 580.50 |
| Sales of JOURNALS | 101.56 |
| Library Fines | 7.70 |
| Engineers' Joint Dinner | 8.09 |
| Waste Paper Sold | 2.59 |
| Interest | 22.06 |
| | $9 699.81 |

*Expenditures.*

| | |
|---|---|
| Journal | $2 721.20 |
| Printing, Postage, Stationery and Library Supplies | 991.67 |
| Rent (net) | 1 640.00 |
| Light | 47.12 |
| Salaries (except Editor) | 2 008.00 |
| Reporting | 46.90 |
| Stereopticon | 59.02 |
| Books | 44.13 |
| Binding | 216.15 |
| Periodicals | 51.00 |
| Incidentals and Repairs | 160.87 |
| Insurance | 35.44 |
| Telephone (net) | 41.16 |
| Sanitary Section Incidentals | 73.25 |
| Annual Meeting and Dinner | 80.42 |
| Students' Meeting | 193.94 |
| Committee on Social Activities | 94.65 |
| Cash on hand, March 1, 1916 | 1 194.89 |
| | $9 699.81 |

FURNISHINGS FUND.

| | |
|---|---|
| Cash balance March, 1915 | $613.52 |
| Furniture Purchased | $554.61 |
| Transferred to Permanent Fund Income | 58.91 |
| | $613.52 |

PERMANENT FUND.

*Receipts.*

| | |
|---|---|
| Cash on hand March, 1915 | $227.73 |
| Entrance Fees | 1 045.00 |
| Contribution | 100.00 |
| Republican Valley R. R. Bond Sale | 600.00 |
| Interest (including $58.91 from Furnishings Fund) | 1 613.25 |
| | $3 585.98 |

*Paid Out.*

| | |
|---|---|
| Coöperative Bank Dues | $825.00 |
| Superior Water, Light & Power Co. Bond Purchased | 842.50 |
| Wheeling Light Securities Co. Bond Purchased | 950.00 |
| Cash on hand, March 1, 1916 | 968.48 |
| | $3 585.98 |

E. K. TURNER FUND.

| | |
|---|---|
| Received from Estate of E. K. Turner | $1 000.00 |

TABLE 2. — COMPARATIVE BALANCE SHEETS.

| | March 19, 1913. | March 18, 1914. | March 17, 1915. | March 1, 1916. |
|---|---|---|---|---|
| **Assets.** | | | | |
| Cash | $353.26 | $119.41 | $1 267.73 | $3 163.37 |
| Bonds and Notes | 26 615.50 | 27 605.50 | 29 191.75 | 30 366.25 |
| Stock | ....... | 1 950.00 | 1 950.00 | 1 950.00 |
| Coöperative Banks | 5 315.80 | 3 545.72 | 3 212.65 | 4 190.96 |
| Accounts Receivable (Rent) | 145.83 | 145.83 | 145.83 | ....... |
| Library | 7 500.00 | 7 500.00 | 7 500.00 | 7 500.00 |
| Furniture | 1 175.65 | 1 325.15 | 1 950.49 | 2 405.11 |
| | $41 106.04 | $42 191.61 | $45 218.45 | $49 575.69 |
| **Liabilities.** | | | | |
| Permanent Fund | $29 933.84 | $31 864.29 | $34 582.13 | $37 475.69 |
| Edmund K. Turner Fund | ....... | ....... | ....... | 1 000.00 |
| Unexpended Appropriations | 1 051.40 | 851.46 | 613.52 | ....... |
| Current Funds | 1 310.15 | 535.71 | 451.31 | 1 194.89 |
| Accounts Payable | 135.00 | 115.00 | 121.00 | ....... |
| Surplus | 8 675.65 | 8 825.15 | 9 450.49 | 9 905.11 |
| | $41 106.04 | $42 191.61 | $45 218.45 | $49 575.69 |

TABLE 3. — INVESTMENT OF THE PERMANENT FUND, MARCH 1, 1916.

| | Par Value. | Actual Cost. | Present Market Value. | Value as Carried on Books. |
|---|---|---|---|---|
| **Bonds.** | | | | |
| American Tel. & Tel. Co. col. tr. 4%, 1929 | $3 000.00 | $2 328.75 | $2 760.00 | $2 737.50 |
| Union Elec. Light & Power Co. 5%, 1932 | 2 000.00 | 2 050.00 | 2 000.00 | 2 050.00 |
| Blackstone Valley Gas & Elec. Co. 5%, 1939 | 2 000.00 | 1 995.00 | 2 000.00 | 1 995.00 |
| Dayton Gas Co. 5%, 1930 | 2 000.00 | 2 000.00 | 1 960.00 | 2 000.00 |
| Milford & Uxbridge St. Ry. 5%, 1918 | 3 000.00 | 2 942.50 | 3 000.00 | 2 942.50 |
| Railway & Light Securities Co. 5%, 1939 | 3 000.00 | 3 000.00 | 2 880.00 | 3 000.00 |
| Superior Light & Power Co. 4%, 1931 | 4 000.00 | 3 347.50 | 3 360.00 | 3 347.50 |
| Wheeling Electric Co. 5%, 1941 | 4 000.00 | 3 845.00 | 3 800.00 | 3 845.00 |
| Economy Light & Power Co. 5%, 1956 | 1 000.00 | 990.00 | 950.00 | 990.00 |
| Tampa Electric Co. 5%, 1933 | 2 000.00 | 2 000.00 | 1 980.00 | 2 000.00 |
| Galveston Houston Elec. Ry. Co. 5%, 1954 | 2 000.00 | 1 940.00 | 1 840.00 | 1 940.00 |
| Northern Texas Elec. Co. 5%, 1940 | 2 000.00 | 1 932.50 | 1 800.00 | 1 932.50 |
| Chicago & Northwestern Ry. 5%, 1987 | 1 000.00 | 1 102.50 | 1 160.00 | 1 102.50 |
| | $31 000.00 | $29 473.75 | $29 490.00 | $29 882.50 |
| **Note.** | | | | |
| Dallas Elec. Co. 5%, 1917 | 500.00 | 483.75 | 495.00 | 483.75 |
| **Stock.** | | | | |
| 15 shares Am. Tel. & Tel. Co. | 1 500.00 | 1 950.00 | 1 912.50 | 1 950.00 |
| Total Securities | $33 000.00 | $31 907.50 | $31 897.50 | $32 316.25 |

**Coöperative Banks.**

| | |
|---|---|
| 25 shares Merchants Coöperative Bank, including interest to March | $1 708.00 |
| 25 shares Volunteer Coöperative Bank, including interest to January | 1 386.10 |
| 25 shares Watertown Coöperative Bank, including interest to December | 1 096.86 |
| | $4 190.96 |
| Total value of Invested Funds | $36 507.21 |
| **Cash on hand** | 968.48 |
| Total value of Permanent Fund | $37 475.69 |
| Edmund K. Turner Fund | 1 000.00 |
| Total value Permanent Funds | $38 475.69 |

## Report of the Auditing Committee.

Boston, Mass., March 15, 1916.

We hereby certify that we have this day examined the books and records of the Treasurer of the Boston Society of Civil Engineers for the year 1915–16; that all receipts are properly accounted for and that there are proper vouchers for all expenditures.

We have also examined the securities and investments of the Society's funds, have verified and compared the same with the books and found them all accounted for and properly carried.

We have compared the financial statement of the Treasurer with the books and find it to be correct.

Edmund M. Blake,
George C. Whipple,
*Directors.*

## Annual Report of the Secretary, 1915–16.

S. Everett Tinkham, Secretary, *in account with the* Boston Society of Civil Engineers. *Dr.*

For cash received during the year ending March 15, 1916:

| | | | |
|---|---|---|---|
| From entrance fees, new members and transfers: | | | |
| 86 members and associates ............... at $10 = | | $860.00 | |
| 32 juniors ............................... at 5 = | | 160.00 | |
| 5 transfers to member ..................... at 5 = | | 25.00 | |
| Total from entrance fees .................. | | | $1 045.00 |
| From annual dues for 1915–16, including dues of new members ........ | | $7 437.83 | |
| From back dues ............................. | | 52.00 | |
| From dues for 1916–17 ...................... | | 61.00 | |
| Total from dues ............................ | | | 7 550.83 |
| From rents ................................. | | | 1 000.00 |
| From advertisements ........................ | | | 1 580.50 |
| From sale of Journals and reprints ......... | | | 101.56 |
| From contribution to building fund ......... | | | 100.00 |
| Total ...................................... | | | $11 377.89 |

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

We have examined the above report and found it correct.

Edmund M. Blake,
George C. Whipple,
*Auditing Committee of Directors of the Boston Society of Civil Engineers.*

## Annual Report of Library Committee, 1915–16.

Boston, Mass., March 15, 1916.

*To the Boston Society of Civil Engineers:*

The Library Committee submits the following report for the year 1915–16.

Since the last report 922 volumes bound in cloth and 504 bound in paper have been added to the library, making a total of 1 426 accessions.

There are now 8 702 cloth-bound volumes in the library. Those bound in paper now number in the vicinity of 2 500, in spite of the amount of binding done during the year, but this estimate includes a considerable number of duplicates which will be eliminated later from collections of pamphlets donated by members.

During the year 335 books have been loaned to members, and fines to the amount of $7.70 have been collected.

There has been an increase, both real and apparent, over previous years, in the amount of binding done. Not only have files begun in past years been brought to completion and bound, but the number of periodicals and society publications bound regularly has increased. The *Electric Railway Journal*, the *Concrete-Cement Age*, the *Canadian Engineer* and the *Journal of the Cleveland Engineering Society* have been added to the publications bound regularly, and the binding of still others is under consideration. The Society's file of the Water-Supply Papers of the United States Geological Survey has been brought up to date, and twenty-two volumes of the same bound during the year.

Twelve new engineering books have been purchased for Section 10, and three others, Volumes I and II of "The Principles and Practice of Surveying," by Messrs. Charles B. Breed and George L. Hosmer, and Volume III of "American Sewerage Practice," by Messrs. Leonard Metcalf and Harrison P. Eddy, have been presented to the library by the authors.

The Society is indebted to Mr. William F. Morse for a complete set of the Transactions of the Fifteenth International Congress on Hygiene and Demography, held in Washington in 1912, and to Mr. Fred M. Twombly for ten volumes of the Proceedings of the American Railway Master Mechanics' Association.

The committee also wishes to acknowledge the Society's indebtedness to Mr. Percy M. Blake, who has donated a considerable number of reports to the library, as well as a number of text-books of historical interest.

At the regular meeting of the Society in June, 1915, the committee presented a set of revised rules for the circulation of the books in the library, which rules were adopted at that meeting and printed in the September issue of the JOURNAL. Chief among the changes made were the limiting of the time for keeping out books to two weeks instead of five, and the provision by which "volumes belonging to a set — such as volumes of bound periodicals and of proceedings of transactions of societies — may be taken from the rooms for a limited time only, by special arrangement with the attendant."

Your committee has for some time been considering a more satisfactory way of stamping the books with the Society's name, and has finally purchased a perforating stamp, the mark of which can be eradicated only by removing the page or portion of a page bearing it.

The report of the Board of Government mentions the fact that under the will of our late associate, Edmund K. Turner, the Society has been the recipient of engineering books to the number of 1 105, and of a further bequest of $1 000, the income of which is to be used for the maintenance of the Society's library. Of the 1 105 books received, only 603 have been placed on the regular shelves and are included in the year's accessions as stated above. The remainder of these volumes consists of reports and bound periodicals, which are duplicates of those already in the library and for which there is not room on the shelves at present. These, if disposed of, would bring only a trifling sum, while it would cost the Society a considerable amount to replace the volumes of which these are duplicates, if obliged to do so through loss by fire, or any other cause. Some of these, in all probability, could not be replaced at all. Your committee therefore recommends that a suitable and safe place be provided for the storage of these and other duplicate volumes of value.

The question of storage room at Society headquarters also calls for attention. The lack of such storage room, both for office supplies and for material donated to the library, pending examination and the elimination of duplicates, is a serious handicap to the work of the library. At present there is no storage room for such material except on the regular shelves, which makes it impossible to keep the latter in a semblance of order, and necessitates innumerable shiftings and handlings over before the material is finally disposed of.

To the furnishings of the library have been added since the last report a second accession case, a new periodical rack and two new steel stacks, these last being made necessary by the unusual number of accessions during the year.

The work of reclassifying and recataloguing the library is still being carried on, and has progressed considerably in spite of interruptions. Section 4, state reports, and Section 10, engineering text-books, have been entirely reclassified and recatalogued; Section 1, society publications, is nearly completed, and Section 5, United States government reports, is well under way.

The committee recommends that a sum not less than one hundred dollars be appropriated for the purchase of current engineering books during the coming year.

S. E. Tinkham,
Frederic I. Winslow,
Henry F. Bryant,
*Committee on Library.*

## Report of the Executive Committee of the Sanitary Section.

Boston, Mass., March 1, 1916.

*To the Sanitary Section, Boston Society of Civil Engineers:*

During the past year, marking the twelfth in the history of the Section, seven meetings were held, the subjects and speakers being as follows:

*March 3, 1915.* — "The Sewage Disposal Works at Fitchburg, Mass.," David A. Hartwell.

*November 3, 1915.* — Excursion to Albany Street pumping station, Boston, at 5 o'clock P.M., followed in the evening by a paper, "The South End Sewer System," Edgar S. Dorr.

*November 24, 1915.* — "Mosquito Extermination Work," Harold I. Eaton.

*December 1, 1915.* — "Proposed Improvements of the Quequechan River, Fall River, Mass.," Frederic H. Fay.

*January 5, 1916.* — "Sanitary Work in the United States Army," Maj. James F. Hall, Medical Corps, U. S. A.

*January 10, 1916.* — "Activated Sludge," Dr. Edward Bartow.

*February 2, 1916.* — "The Reconstruction of the Cambridge, Ohio, Water Works," W. J. Sherman.

Preliminary arrangements were made for a meeting in June, but as it seemed best to join with the main Society and the New England Water Works

Association in the excursion to Pemberton, the speaker, Prof. C. F. Binns, addressed the regular meeting of the Society, instead of the Section, on "The Application of Clay Products to Some Engineering Problems."

Of the papers presented, two have been published, a third is available for publishing, and it is hoped to obtain the manuscript for two others.

All of the papers have been illustrated by lantern slides.

Owing to the increasing attendance at the Section meetings, they have been held in various places, as the opportunity offered. Three have been held in the Society library, two in Myers Hall, and two in Gilbert Hall, Tremont Temple.

An experiment or innovation has been tried by serving a cafeteria supper at three of the meetings. The arrangements and price seemed to find popularity. By this means, it was also possible to begin the meeting a half hour earlier, which is of considerable advantage to out-of-town members.

The record of attendance is as follows:

| Date | Attendance. Dinner. | Meeting. |
|---|---|---|
| March 3, 1915 (annual meeting) | 36 | 61 |
| November 3, 1915 excursion) | .. | 64 |
| November 3, 1915 | .. | 32 |
| November 24, 1915 | .. | 54 |
| December 1, 1915 | 90 | 113 |
| January 5, 1916 | 80 | 122 |
| January 10, 1916 | .. | 65 |
| February 2, 1916 | 32 | 38 |

Average attendance at seven meetings, excluding the November excursion, was 69.

Five new members have been added during the year, making present total membership of the Section 174, of whom 9 are members of the Sanitary Section only, 4 are juniors and 1 an associate.

Arrangements have been made for a meeting, April 5, on the subject, "The Design and Use of Catch Basins." It is hoped to make this an experience meeting that will be valuable to all.

Preliminary arrangements have been made for a meeting in May on sanitary and hydraulic work in Hawaii.

It is recommended that the Board of Government of the Society be requested to consider and, if possible, take measures to provide for definite quarters where the meetings of the Sanitary Section may be held.

It is suggested that when the next notices are sent to members of the Society concerning a Section meeting, that an invitation be extended to non-members who are interested in sanitary matters to affiliate with the Section.

It is recommended that the incoming Executive Committee be requested to consider the advisability of the appointment of a special committee to standardize the nomenclature and technical terms of sanitary engineering or such branch thereof as they may deem advisable.

Respectfully submitted for the Executive Committee,

Frank A. Marston, *Clerk*.

## Report of the Committee on Social Activities.

Boston, Mass., March 15, 1916.

To the Board of Government, Boston Society of Civil Engineers:

*Gentlemen,* — The Committee on Social Activities, appointed by you in the spring of 1915, has the honor to report as follows:

Five informal dinners have been held during the year, on May 19, October 20, November 17, December 15, 1915, and January 26, 1916. A joint excursion and dinner with the New England Water Works Association, including ladies, was held on June 16, 1915. No informal dinner was planned for February, 1916, on account of the joint annual dinner of the mechanical, electrical and civil engineers, which came during that month. The informal dinners have in every case preceded the regular meetings of the Society.

The detail record of attendance at these dinners and the excursion is:

| Date. | Members. | Guests. | Total. |
|---|---|---|---|
| May 19, 1915 | 78 | 12 | 90 |
| October 20, 1915 | 83 | 40 | 123 |
| November 17, 1915 | 75 | 20 | 95 |
| December 15, 1915 (ladies' night), | 77 | 41 | 118 |
| January 26, 1916 | 73 | 22 | 95 |

| | |
|---|---|
| Average attendance at the dinners | 104 |
| Average attendance, 1914–1915 dinner | 84 |
| Gain in average attendance | 20 |
| Percentage of gain in attendance, about | 24% |
| Average attendance of members, 1915–1916 | 77 |
| Average attendance of members, 1914–1915 | 66 |
| Gain in average attendance of members | 11 |
| Percentage of gain in attendance of members, about | 17% |

Joint excursion, June 16, 1915:

| | Members. | Guests. | Total. |
|---|---|---|---|
| Attendance | 146 | 74 | 220 |

The May 19 dinner was held at the City Club, with Mr. Harrison P. Eddy as toastmaster.

The June 16 excursion was held at Pemberton. On this occasion, the Society's baseball team defeated the New England Water Works Association team, 20–7, winning the first championship of the annual series and the coveted medals. Mr. George F. Merrill acted as toastmaster at the dinner in the Pemberton Inn following the game.

As a record, the box score of the game is presented herewith:

| Boston Society C. E. | R. | H. | P. | A. | E. |
|---|---|---|---|---|---|
| Cashman, 2b | 2 | 1 | 1 | 0 | 0 |
| Bryant, ss., p. | 4 | 1 | 0 | 6 | 1 |
| Andrews, c. | 3 | 3 | 11 | 0 | 4 |
| Ambrose, cf. | 1 | 3 | 0 | 0 | 0 |
| Sampson, p., ss. | 2 | 2 | 0 | 6 | 0 |
| Craig, rf. | 2 | 2 | 0 | 0 | 0 |
| Coghlan, lf. | 3 | 2 | 0 | 0 | 0 |
| Gammage, 3b. | 3 | 3 | 0 | 1 | 0 |
| Wason, 1b. | 0 | 0 | 2 | 0 | 2 |
| Totals | 20 | 17 | 14* | 13 | 7 |

* Allen hit by batted ball.

| N. E. W. W. Association. | R. | H. | P. | A. | E. |
|---|---|---|---|---|---|
| Conley, 3b. | 1 | 0 | 2 | 1 | 1 |
| Heffernan, 1b, c. | 1 | 0 | 2 | 0 | 2 |
| Glavin, c., 1b. | 1 | 2 | 7 | 0 | 8 |
| Allen, ss. | 0 | 1 | 0 | 0 | 0 |
| Hersey, p., c. | 2 | 1 | 0 | 5 | 1 |
| Johnson, lf. | 1 | 2 | 1 | 0 | 0 |
| McBride, rf. | 1 | 1 | 0 | 0 | 1 |
| Sherman, cf. | 0 | 1 | 3 | 0 | 0 |
| Mulque, 2b. | 0 | 0 | 0 | 0 | 1 |
| Symond, p. | 0 | 0 | 0 | 3 | 0 |
| Simmons, 3b. | 0 | 0 | 0 | 0 | 0 |
| Totals | 7 | 8 | 15 | 9 | 14 |

Time of game: 1.45. Umpires: James W. Rollins and W. S. Johnson.

The October dinner was held at the City Club, following a joint excursion to the new Salem water works with the New England Water Works Association in the afternoon. President Charles R. Gow presided and the entertainment was furnished by Scott & Bayrd, the famous two-man minstrel show, whose jokes were localized.

The November dinner was held at the City Club, with President Charles R. Gow as toastmaster. The principal guest and speaker of the evening was the Hon. Calvin Coolidge, of Northampton, lieutenant-governor-elect of Massachusetts, who spoke on the "Relation of the Engineer to the Public Service of the State." Mr. Frank W. Stearns, manager of Mr. Coolidge's campaign, was also a guest.

The December dinner was served in Chipman Hall by Jesse Dill. It was ladies' night and 41 were present to grace the occasion. Entertainment was furnished by Miss Katherene Kelley, a charming story-teller, and by Josaf Yarrick, a clever magician.

The January dinner was held at the City Club, with Mr. Charles H. Eglee as toastmaster. The honor guests and speakers of the evening were Ralph A. Stewart, Esq., of Choate, Hall & Stewart, who spoke on the "Relation of the Engineer to the Legal Profession," and Mr. Wilfrid Wheeler, secretary of the State Board of Agriculture, who spoke on the "Development of the Agricultural Resources of the State." It was at this dinner, also, that Mr. Henry A. Symonds read his now famous "Post-Mortems with St. Peter."

Mr. Edwin R. Olin has acted as "Choragus" at all of these dinners, and under his able leadership mass singing has continued to improve, becoming one of the pleasantest features of these social occasions.

The personnel of the committee has been as follows: Edmund M. Blake, chairman; Charles H. Eglee, Frederic C. H. Eichorn, Clarence T. Fernald, N. LeRoy Hammond, Laurence B. Manley, Edwin R. Olin, David S. Reynolds, Charles W. Sherman, Henry A. Symonds. We have continued to make every effort possible to bind the membership of the Society more closely together and to build up and foster a strong social spirit based upon good fellowship. We feel that our work is showing the most encouraging results, not alone as evidenced by the large increase in the average attendance at the dinners, but even more by the very evident gain in fraternal *esprit de corps*. We believe that on the building up and encouragement of this social spirit will depend to a large extent the ultimate strength of our organization in the communities we represent, and we have sincerely appreciated the responsiveness of the membership to our past endeavors.

Respectfully submitted for the Committee,

EDMUND M. BLAKE,
*Chairman Committee on Social Activities.*

## REPORT OF THE EDITOR OF THE JOURNAL.

BOSTON, MASS., January 25, 1916.

TO THE BOARD OF GOVERNMENT OF THE
BOSTON SOCIETY OF CIVIL ENGINEERS:

*Gentlemen,* — I have the honor to submit the following report on the JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS for the year 1915.

The JOURNAL was issued monthly, except in July and August, ten numbers being issued and 1 200 copies of each number being printed. As there were 1 112 copies used for the December mailing list, and as about a dozen copies are used each month for samples and to cut up for editorial purposes, we have now no more than 75 spare copies of each issue left on hand. This is ordinarily an ample supply, but if the membership of the Society continues to increase, the number printed will have to be enlarged.

The JOURNAL contained 18 papers, discussions of 8 papers and 7 memoirs of deceased members. A total of 742 pages was printed in the ten issues, with 49 cuts and 5 inserted plates, at a gross cost of $2 726.11. Although a considerable amount of new advertising was secured, the total amount in the December issue was slightly less than at the first of the year. The loss of two full-page advertisements accounts for most of this. The total receipts from advertisements, $1 456.50, were, nevertheless, slightly larger than in 1914. Deducting this amount, together with the sums received for subscriptions and sales of JOURNALS, the total net cost of the JOURNAL was $1 193.62, or an average of $119.36 per issue. From the total might be deducted the balance of about $8 credited to us at the post office, which would reduce the average net cost to about $118.50 per issue. It is interesting to compare this average net cost of $118.50 with the figure of $177.80 for nine issues of 1914* and $160 estimated by the Committee on Publication in 1913. As the number of pages printed was less in 1915 than in 1914, the average net cost per page offers a still better comparison. Based on the 1913 estimate, it was $2.10, for nine issues in 1914 it was $2.09, and in 1915 it was $1.61.

This low cost per page is mainly due to two facts; that many of the papers published have not been illustrated and that the cuts for one of the well-illustrated papers were furnished by the author.

The details of the number of pages printed and of the costs are given in the accompanying table.

Respectfully submitted,

EDWARD C. SHERMAN, *Editor.*

* The last nine issues of 1914 are used for comparison, as the January number was an exceptionally expensive one. See Report of the Editor in JOURNAL, April, 1915.

| Month. | Pages of: Papers. | Pages of: Proc. | Pages of: Index. | Pages of: Adv. | No. of: Inserts | No. of: Cuts. | Cost of: Papers, Proc. and Index. | Cost of: Cuts. | Cost of: Adv'ts. | Cost of: Reprints. | Cost of: Postage, Wrapping and Mailing. | Cost of: Editing. | Cost of: Comms. on Adv'ts. | Cost of: Editor's Incidentals. | Cost of: Copy. and Revenue Tax. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 48 | 16 | | $18\frac{3}{4}$ | | 2 | $160.93 | | $19.43 | $10.00 | $18.10 | | | $0.57 | |
| Feb. | 42 | 16 | | $18\frac{3}{4}$ | | 0 | 173.80 | | 21.91 | 10.00 | 20.70 | | | .43 | |
| Mar. | 44 | 14 | | $18\frac{1}{2}$ | | 4 | 148.30 | $9.05 | 21.15 | 9.00 | 28.38 | | $15.00 | .33 | |
| Apr. | 34 | 39 | | $18\frac{1}{2}$ | | 0 | 209.15 | | 17.35 | 18.00 | 19.52 | | 22.50 | .40 | |
| May | 34 | 14 | | $18\frac{1}{4}$ | | 5 | 141.89 | 8.40 | 21.23 | 10.00 | 19.77 | | 8.75 | .12 | |
| June | 58 | 10 | | $17\frac{1}{4}$ | 4 | 12 | 277.70 | | 18.01 | 27.50 | 25.91 | | 9.37 | .11 | |
| Sept. | 26 | 15 | | $17\frac{1}{2}$ | | 9 | 132.70 | 11.00 | 24.44 | 14.00 | 21.31 | | 27.50 | 3.10 | |
| Oct. | 46 | 10 | | $17\frac{1}{2}$ | | 4 | 147.70 | 5.80 | 18.78 | 15.00 | 19.85 | | 20.00 | .45 | |
| Nov. | 18 | 15 | | $18\frac{1}{4}$ | | 6 | 103.75 | 10.50 | 25.18 | 7.00 | 30.77 | | 10.62 | 64 | |
| Dec. | 24 | 12 | 9 | $17\frac{1}{4}$ | 1 | 7 | 136.95 | 17.00 | 24.58 | 9.00 | 19.26 | | 34.38 | 1.09 | |
| Total | 374 | 161 | 9 | $180\frac{1}{2}$* | 5 | 49 | $1 632.87 | $61.75 | $212.06 | $129.50 | $223.57† | $300.00 | $148.12 | $7.24 | $11.00 |

Total number of pages, 742.

| | | |
|---|---|---|
| Total gross cost | | $2 726.11 |
| Subscriptions | $40.50 | |
| Sales of JOURNALS | 35.49 | |
| Advertisers | 1 456.50 | |
| | | 1 532.49 |
| Total net cost | | $1 193.62 |

* 198 pp. used. Not all set solid.

† Balance at post office, about $8.

## APPLICATIONS FOR MEMBERSHIP.

[April 4, 1916.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

COBURN, FRANK RUNDLETT, Watertown, Mass. (Age 23, b. Cambridge, Mass.) Student at Mass. Inst. of Technology during year 1910–11. From 1911 to 1912, inspector of construction with sewer department, Watertown, Mass.; from 1912 to August, 1914, in business with F. J. Maynard, under name of Maynard & Coburn, engineers and surveyors, Watertown; from August, 1914, to date, inspector in conduit department with Edison Elec. Ill. Co. Refers to E. L. Johnson, W. F. Learned, O. F. Mann, F. J. Maynard and W. B. Snow.

CYR, JOHN P., Nashua, N. H. (Age 28, b. Pembroke, N. H.) Graduate of Nashua High School; received technical education from correspondence courses in mechanical drawing and structural engineering. During fall of 1906, timekeeper and rodman for City of Nashua; during 1907 and 1908, with Engrg. Dept., City of Nashua, first as rodman and later as transitman; during 1909 and 1910, assistant engineer with Erwin O. Hathaway, U. S. Senior Highway Engr., Nashua; from 1910 to date, assistant engineer, City of Nashua; during fall of 1915, was supervising engineer for City of Nashua and Town of Merrimack on construction of reinforced concrete bridge. Refers to A. W. Dean, W. M. Foster, E. O. Hathaway and W. F. Sullivan.

HANNAH, THOMAS EWING, Boston, Mass. (Age 21, b. Fitchburg, Mass.) Student at Mass. Inst. of Technology, class of 1917; attended Mass. Inst. of Technology Surveying Camp during summer of 1915. Refers to C. F. Allen, C. B. Breed, J. W. Howard and C. M. Spofford.

Holmes, Harry Emery, Everett, Mass. (Age 40, b. Medford, Mass.) Graduate of Tufts College, engineering department, class of 1899. From 1899 to 1901, with Metropolitan Water Department; during 1901, with State Board of Health; from 1901 to 1902, with Metropolitan Sewer Department; during 1903, with City of Medford, city engineer's office; from 1904 to 1905, with W. N. Pike & Sons, building contractors; from 1906 to 1909, resident engineer, with E. Worthington, on construction of sewers and water works; from 1909 to 1910, resident engineer in charge of sewer construction, with F. A. Barbour; from 1910 to 1911, with Town of Brookline, engineer's office, in charge of sewer and road construction; from 1911 to date, with Massachusetts State Board of Health. Refers to E. M. Blake, H. H. Chase, F. A. Barbour, C. R. Gow, A. D. Weston and R. M. Whittet.

Nawn, Leo Joseph, Roxbury, Mass. (Age 21, b. Boston, Mass.) Educated in Boston public schools, Stone and Volkman preparatory schools and at Worcester Academy. During part of summer of 1911, clerk on underground conduit construction; summers of 1912, 1913 and 1914, sub-foreman for Hugh Nawn Contracting Company on construction of Boylston Street subway; from September, 1915, to date, clerk and sub-foreman for the same firm. Refers to J. H. Coghlan, F. P. Donovan, G. W. Lewis, Hugh Nawn and L. L. Street.

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## LIST OF MEMBERS.

### ADDITIONS.

Bean, Thomas W. .......... Turners Falls, Mass.
Cross, Ralph U. .......... Delta Upsilon House, Tufts College, Mass.
Hood, Ralph D. .......... 50 Merrimack St., Haverhill, Mass.
Howard, David R. .......... 241 Winter St., Woonsocket, R. I.
Luther, Royal .......... Box 467, Portland, Me.
Peabody, Dean, Jr. .......... 128 Summer Ave., Reading, Mass.
Peacock, Frank E. .......... 535 Newbury St., Boston, Mass.
Whitney, Ralph E. .......... 84 Huntington Ave., Boston, Mass.

### CHANGES OF ADDRESS.

Armstrong, Kenneth P., care Interstate Commerce Comm.,
Div. of Valuation, Eastern Dist., Washington, D. C.
Bessey, Roy F. .......... Care Nichols Copper Co., Laurel Hill, L. I., N. Y.
Brown, Wm. A., .......... 111 Devonshire St., care H. S. Kimball, Boston, Mass.
Denley, Alfred N. .......... 50 Cutting St., Winchester, Mass.
Drummond, Wm. W. .......... Ft. Moultrie, Moultrieville, S. C.
Eisnor, John J. .......... 41 Medford St., Medford, Mass.
Ferris, Raymond W. .......... 33 Orchard Road, Akron, Ohio
Grover, Arthur C. .......... 55 Evergreen St., Rutland, Vt.
Harrington, Walter .......... 629 So. Broadway, Los Angeles, Calif.

Kendall, Theodore R. .......... Box 116, Gatun, C. Z.
Leary, Charles A. .......... 36 Beach Ave., Swampscott, Mass.
Lovis, Andrew M. .......... Room 212, State House, Boston, Mass.
Negus, Arthur I. .......... Box M, East Bridgewater, Mass.
Savage, J. Dana .......... Commercial Bldg., Woonsocket, R. I.
Shedd, George G. .......... 167 Myrtle St., Manchester, N. H.
Snow, Leslie W. .......... 8 Story St., Cambridge, Mass.
Sokoll, Jacob M. .......... 129 Cumberland St., Cumberland Mills, Me.

DEATH.

Leavitt, Erasmus Darwin .......... March 11, 1916.

RESIGNATIONS.

(In effect March 15, 1916.)

Alexander, E. Porter
Bugbee, Julius W.
Colman, Arthur N.
Dodge, Samuel D.
Ferguson, Hardy S.
Kennedy, Frank L.
Mansur, George W.
Mason, Franklin L.
Morrow, Clarence E.
Mosher, Percival H.
Olson, Edward F.
Parlin, Raymond W.
Schwartz, Samuel
Smith, Arthur H.
Snow, Walter B.
Sprague, Harry R.
Taylor, Charles M.

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## EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### Men Available.

351. Age 33. Graduate of Tufts College, class of 1906. Has had nine years' experience, chiefly on hydraulic and reinforced concrete design; experience includes $3\frac{1}{2}$ years as assistant engineer on design of Catskill Aqueduct and 3 years as hydraulic designer on important water-power development; is associate member Am. Soc. C. E. Desires position as hydraulic and reinforced concrete designer. Salary desired, $1 800 per year.

352. Age 26. Student for four years (1906–1910) at Harvard Col. and

Graduate School of Applied Science, receiving degree of A.B. in 1909. Has had about six years' experience, chiefly on hydraulic development; has served in various capacities, including that of resident engineer on canal excavation, with some cofferdam and tunnel work; dam with sluice gates; and completion of hydro-electric station. Desires design, construction or management work along engineering lines.

353. Age 38. Educated in public schools. Has had about twenty years' experience as rodman, instrumentman, draftsman, sewer inspector and foreman of laborers. Desires position as inspector, transitman or draftsman.

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## LIBRARY NOTES.

### Recent Additions to the Library.

**U. S. Government Reports.**

Shorter Contributions to General Geology, 1915. David White.

Mineral Production of United States in 1914. H. D. McCaskey.

Structure of Berea Oil Sand in Summerfield Quadrangle, Ohio. D. Dale Condit.

Structure of Berea Oil Sand in Woodsfield Quadrangle, Ohio. D. Dale Condit.

Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory near Honolulu, Hawaii, 1913 and 1914. Daniel L. Hazard.

Spruce and Balsam Fir Trees of Rocky Mountain Region. George B. Sudworth.

Water-Supply Papers 359, 372, 385, 397.

**State Reports.**

New York. Annual Report of State Engineer and Surveyor for 1914, Vols. I and II.

Wisconsin. Mineral Land Classification. W. O. Hotchkiss and others.

Wisconsin. Underground and Surface Water Supplies of Wisconsin. Samuel Weidman and Alfred R. Schultz.

Wisconsin. Soil Survey Bulletins 28 to 32 and 37 to 40, with maps. A. R. Whitson and others.

**Municipal Reports.**

Belmont, Mass. Annual Report of Water Commissioners for 1915.

Brockton, Mass. Annual Report of Water Commissioners for 1915.

Concord, Mass. Annual Report of Board of Health for 1915.

Concord, Mass. Annual Report of Road Commissioners for 1915.

Concord, Mass. Annual Report of Water and Sewer Commissioners for 1915.

Detroit, Mich. Annual Report of Water Commissioners for 1915.

Laconia, N. H. Annual Reports of Board of Public Works for 1915.

Manchester, Mass. Annual Reports of Sewer Commissioners for 1914 and 1915.

Peabody, Mass. Annual Report of Commission of Public Works for 1915.

Plainfield, N. J. Annual Report of City Officers for 1915.

Reading, Mass. Annual Report of Water Commissioners for 1915.

Rutland, Vt. Annual Report of City Officers for 1915.

Wellesley, Mass. Annual Reports of Water and Municipal Light Commissioners for 1915.

Westfield, Mass. Annual Report of Municipal Light Board for 1915.

**Miscellaneous.**

Industrial Arts Index for 1915.

International Engineering Congress, 1915: Transactions. — Panama Canal, Vols. I and II.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

**Commonwealth of Massachusetts.**—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.*

*Sudbury Dam Hydro-Electric Plant.* — Two 24-in. turbines have been set in place, and the 900 K. V. A. generator has been delivered. The overhead transmission line is being erected.

METROPOLITAN PARK COMMISSION. — *Charles River Reservation.* — The work of building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown, is in progress. A. G. Tomasello, contractor.

Plans are being prepared for bridge over the Charles River at Commonwealth Ave., between Newton and Weston, and bids will be asked for the work about the first of April.

Work of excavating channel of Charles River from Elm St. to Bleachery Dam, Waltham, is in progress. John R. Burke, contractor.

*Alewife Brook Parkway.* — Bids were received on March 27 for surfacing and finishing Alewife Brook Parkway, from Massachusetts Ave. to Powder House Boulevard.

*Furnace Brook Parkway.* — Work of construction of parkway extension from Quincy Shore Reservation to Hancock St. is in progress. John Cashman and Sons Company, contractor.

Work of building reinforced concrete girder bridge across Blacks Creek, for Furnace Brook Parkway Extension, is in progress. Hugh Nawn Contracting Company, contractor.

*Mystic Valley Parkway.* — Work of excavating the channel of Aberjona River from Boston & Maine Railroad Bridge to Waterfield Street is in progress. Coleman Brothers, contractors.

*Old Colony Parkway.* — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

Directors of the Port of Boston. — *Reclamation of Flats at East Boston.* — Under contract with the Bay State Dredging and Contracting Co. a portion of the bulkhead has been constructed, and 75 000 cu. yds. of filling placed adjacent to and along the axis of the bulkhead preliminary to driving the sheeting. This material has been dredged from the northerly side of the anchorage basin, east of the main ship channel.

The Directors received bids on March 6, 1916, for dredging and depositing 1 000 000 cu. yds. of material upon an area of State Flats north of the bulkhead now under construction. Prices per cu. yd. ranged from $0.1547 to $0.1875. The contract was awarded to the lowest bidder, the Atlantic, Gulf & Pacific Co. of New York, on March 14, 1916, and approved by the Governor and Council on March 21, 1916.

This material will be deposited by the hydraulic process and will reclaim about 35 acres of flats. The source of this material is a receiving basin already maintained northwest of Governors Island, and into which have been deposited, by scows, about 600 000 cu. yds. of material dredged from various parts of Boston Harbor.

In addition to this material, the Directors propose to deposit in this basin for rehandling about 450 000 cu. yds. of material to be dredged from Mystic River under another contract at the rate of about 80 000 cu. yds. per month.

*Mystic River Dredging.* — On March 6, 1916, bids were received for the excavation of 450 000 cu. yds. of material from a large shoal in Mystic River, westerly from Chelsea Bridge. The prices received varied from $0.1185 to $0.218 per cu. yd. The contract was awarded to the lowest bidder, the Maryland Dredging & Contracting Company of Baltimore, on March 7, 1916. The Governor and Council approved of this contract on March 21, 1916.

The depth of water to be obtained will be 30 ft. at mean low water. The material excavated may be disposed of by dumping within a receiving basin located northwesterly of Governors Island.

*Dry Dock.* — Some progress has been made on work at the dry dock, under contract with the Holbrook, Cabot & Rollins

Corporation. The contractor has continued to assemble plant and materials, including granite for the lining of the dock. The construction of the cofferdam has continued, and dredging of about 260 000 cu. yds. has been done to date.

*Wollaston Yacht Club Channel.* — Dredging at the Yacht Club Channel at Wollaston has been resumed. The total amount dredged to date is about 75 000 cu. yds. of material.

*Extension of Northern Avenue.* — The proposed extension of Northern Ave. from its present terminus near the Commonwealth Pier 6 to the dry-dock will provide a main line of travel from the city to the dry-dock. The Directors propose to build a portion of this by the construction of about 1 000 ft. of timber bulkhead, back of which may be received and dumped cinders and other suitable material as foundation for the roadway. Bids for the construction of this bulkhead will be received at an early date.

**Boston Transit Commission.** — *Dorchester Tunnel.* — Descriptions of Section D, E, G and H were printed in the JOURNAL in October and December, 1915.

Section D includes the station under Dewey Square, to be known as South Station Under. The interior finish on the walls consists of terrazzo and mosaic tile, above which is white Portland cement plaster, which is nearing completion. Escalators of the cleat type are being installed and shelters of polished granite and concrete are being erected over the entrances and exits of the station. Doors, handrails and other items of station finish are under construction.

In Section E both shields are under the channel, the one for the easterly tunnel being within about 500 ft. and the one for the westerly tunnel within about 900 ft. of the northerly end of the section, where they will meet the completed tunnel at the easterly end of Section D under Summer Street. About three fourths of the construction of Section E is done.

On Section G, construction by the tunnel method of the 3 ft. by 5 ft. and 4 ft. 9 in. intercepting sewer in Dorchester Ave. is in progress.

The pump well at B St. is completed, and the excavation for the incline and for the tunnel by open cut between West Fourth and B Sts. in Dorchester Ave. is in progress. Tongued and grooved sheeting is being driven.

**Boston Elevated Railway Company, Bureau of Elevated and Subway Construction.** — *Egleston Square Station.* — Work on the changes to the Egleston Sq. Station is under way. Contracts for the steel work have been awarded and work upon the foundations, drainage and track work is about to begin on the site of the old Egleston Sq. car barn adjacent to the Egleston Sq. Station. A prepayment area is to be established.

*Everett Extension.* — Contract for the foundations for the Mystic River Bridge and Viaduct, and reconstruction of Malden Bridge, has been awarded to the Hugh Nawn Contracting Company, and active construction is about to begin.

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Seventeen submarine boats for the U. S. Government.

One submarine for the Spanish Government.

Three torpedo boat destroyers for the U. S. Government, *Tucker*, *Sampson* and *Rowan*.

Four oil boats for the Texas Co.

Three molasses boats for the Cuba Distilling Co.

Five freight steamers for the Luckenbach Co., Inc.

One tank steamer for the Argentine Government.

Two steel tank steamships for the Petroleum Products Co.

Vol. III MAY, 1916 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, MAY 17, 1916,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Thomas C. Atwood will present a paper entitled, "The Yale Bowl." The paper will be illustrated with lantern slides.

S. E. TINKHAM, *Secretary.*

## PAPERS IN THIS NUMBER.



### CURRENT DISCUSSIONS.

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "Spillways of Panama Canal." | E. C. Sherman. | April. | Aug. 10. |
| "Latest Method of Sewage Disposal." | E. Barton. | April. | Aug. 10. |
| "Service for the Society." | E. M. Blake. | April. | Aug. 10. |

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## MINUTES OF MEETING.

Boston, April 21, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening in the Assembly Room of the Engineers Club, and was called to order at 8 o'clock by the President, Richard A. Hale.

There were 82 members and guests present, including a number of members of the Boston Section of the American Institute of Electrical Engineers and of the American Society of Mechanical Engineers, who had been invited to join in the meeting.

By vote, the record of the annual meeting as printed in the April Journal was approved.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Thomas Allen Appleton, Selden John Gulesian and John T. Scully.

Junior — Samuel Morrison Ellsworth.

Mr. Joseph S. Craigue, a former member of the Society, had been reinstated to membership.

The Secretary also announced that the Board, under authority of a vote passed at the annual meeting, had appointed the following committees of the Society:

On the Library — S. Everett Tinkham, chairman; Henry F. Bryant, Frederic I. Winslow.

On Publication — Charles W. Sherman, chairman; George A. Carpenter, DeWitt C. Webb, George C. Whipple, Sanford E. Thompson, Arthur W. Dean.

On Membership — Charles R. Gow, chairman; Burtis S. Brown, Edward F. Rockwood.

On Papers and Program — Richard A. Hale, chairman *ex officio*; Lewis E. Moore, Sturgis H. Thorndike, Edmund M.

Blake, Edward H. Rockwell, George E. Russell, Robert Spurr Weston, Charles B. Breed, S. Everett Tinkham.

On Social Activities — Henry A. Symonds, chairman; David A. Ambrose, Edwin R. Olin, Charles H. Eglee, Alfred E. Burton, Dana M. Wood, George A. Sampson.

The report of the Board of Government on Permanent Bench Marks about Boston, printed in the April JOURNAL, was then considered, and on motion of Mr. Gow it was voted to refer the matter back to the Board with full power to appoint a member to represent the Society on the committee suggested, should the Board deem it advisable.

The Secretary presented a memoir of John H. Gerrish, an associate of the Society, prepared by a committee consisting of Frank W. Hodgdon and John L. Howard. By vote, the memoir was accepted and ordered printed in the JOURNAL.

The President then introduced Dr. Alexander C. Humphreys, president of the Stevens Institute of Technology and a past president of the American Society of Mechanical Engineers, who read a carefully prepared paper entitled, "Reform and Regulation." The paper considered the question of reform in the regulation of public-service utilities.

The paper was discussed by Prof. D. C. Jackson and Past President Frederic P. Stearns of the Society, and by the Hon. Alonzo R. Weed, chairman of the Board of Gas and Electric Light Commissioners of Massachusetts. A discussion prepared by Mr. J. Parker Snow was also presented, but on account of the lateness of the hour was not read. It will be printed, however, in the JOURNAL.

The thanks of the Society were extended by a rising vote to Dr. Humphreys, for his kindness in presenting his valued paper.

Adjourned.

S. E. TINKHAM, *Secretary.*

## EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### MEN AVAILABLE.

354. Age 22. Graduate of Malden High School, scientific course, 1913, and of Lowell Inst., structural course, 1915. Has had over two years' experience, including work as time, stock and cost data clerk on Commonwealth Pier, and as rodman and instrumentman on survey for railway valuation department. Desires position along civil or mechanical lines. Will accept position at $50 per month, if permanent and with chance to advance.

355. Age 25. Received technical education at Thayer School of Civil Engineering, Dartmouth College. Has had two and one-half years' experience in municipal work, including drafting, transit work, and inspecting. Salary desired, $75 per month.

356. Age 22. Student for three years at Mass. Inst. of Technology; has taken work at summer surveying camp. Has had eight months' experience as rodman, draftsman and transitman with civil engineer; also one fall and winter's experience as draftsman and assistant engr. with underground department of Bay State St. Ry. Desires position for summer as chief-of-party or assistant engr.; will be available June 19. Salary desired, $20 per week.

357. Age 20. Student for three years at Tufts College Engineering School. Has had three months' experience as chainman, levelman and transitman and in general office work. Desires position as rodman, levelman or transitman. Salary desired, $15 per week.

358. Age 32. Received technical education at Mass. Inst. of Technology. Has had experience as follows: two years on municipal improvements, water works, sewerage, etc.; two years in consulting engineer's office, on investigations and reports, water-power development, water supplies, etc.; seven years as contracting engineer and superintendent, on steel, brick, concrete — plain and reinforced — cofferdams, etc.; has also had experience as executive, in buying, etc. Is open to any reasonable offer.

## LIST OF MEMBERS.

### ADDITIONS.

Breen, Charles H. . . . . . . . . . . . . . . . . . . . . . . . 131 State House, Boston, Mass.
Gulesian, Selden J. . . . . . . . . . . . . . . . . . . . . . . 10 Mechanic St., Boston, Mass.
Scully, John T. . . . . . . . . . . . . . . . . . . . . . . . 185 Devonshire St., Boston, Mass.

### CHANGES OF ADDRESS.

Dotten, William J. . . . . . . . . . . . . . . . . . . . . . . 520 Medford St., Malden, Mass.
Gray, Thomas F. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Tufts College, Mass.
Mann, Oswell F. . . . . . . . . . . . . . . . . . . . . . . 26 Bartlett St., Somerville, Mass.
McCorkindale, Ralph I. . . . . . . . . . . . . . . . . . . Box 108, New Bedford, Mass.
Reed, Leslie P.
With Bay State Dredging and Contracting Company, Charles River, Mass.
Rountenberg, Henry W. . . . . . . . . . . . . P. O. Box 24, Richardson Park, Del.
Spalding, Frederic P. . . . . . . . . . . . . . . . . . . 204 Alford St., Charlestown, Mass.
Wentworth, John P. . . . . . . . . . . . . . . . . . . . . 66 Sprague St., Malden, Mass.
Whitmore, Harold C. . . . . . . . . . . . . . . . . . . . . . . 91 Baker St., Lynn, Mass.

### DEATH.

Ross, Charles W. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . April 11, 1916.

### RESIGNATIONS.

(In effect March 15, 1916.)

Beola, Pablo
Blood, John Balch
Curtis, Louville
Dalton, Marshall
Oakes, John J.
Wiley, Walter T.

## LIBRARY NOTES.

### Recent Additions to the Library.

**U. S. Government Reports.**

Evaporation of Brine from Searles Lake, California. W. B. Hicks.

Comparative Financial Statistics of Cities under Council and Commission Government, 1913 and 1915.

Geology and Oil Prospects of Cuyama Valley, California. Walter A. English.

Mineral Resources of United States, 1914, 2 vols. Part I, Metals; Part II, Non-metals.

Reconnaissance for Phosphate in Salt River Range, Wyoming. G. R. Mansfield.

Notes on Promontory District, Utah. B. S. Butler and V. C. Heikes.

Methods for Determination of Physical Properties of Road-Building Rock. Frank H. Jackson.

Relation of Mineral Composition and Rock Structure to Physical Properties of Road Materials. E. C. E. Lord.

Water-Supply Papers 369 and 375-G.

Care and Improvement of the Wood Lot. C. R. Tillotson.

**State Reports.**

Maine. Annual Report of Public Utilities Commission for 1915, Vol. 1.

New Jersey. Annual Report of Commissioner of Public Roads for 1915.

New York. Annual Report of Public Service Commission for First District for 1913, Vol. 1.

**Municipal Reports.**

Brookline, Mass. Annual Report of Water Board for 1915.

Fall River, Mass. Annual Report of Watuppa Water Board for 1915.

Leominster, Mass. Annual Report of Water Board for 1915.

Milwaukee, Wis. Annual Reports of Sewerage Commission for 1914 and 1915.

Newton, Mass. Annual Report of Water Commissioner for 1914.

North Adams, Mass. Annual Reports of City Officers for 1915.

North Adams, Mass. Annual Report of Department of Public Works for 1915.

Northampton, Mass. Annual Report of Water Commissioners for 1915.

Plymouth, Mass. Annual Report of Water Commissioners for 1915.

Springfield, Mass. Annual Report of Water Commissioners for 1915.

Springfield, Mass. Office Reference Pamphlet, 1915.

**Miscellaneous.**

L'Asie Mineure et les Turcs en 1875. Auguste Choisy.

Canals of Canada. Thomas C. Keefer.

Ice Floods and Winter Navigation of Lower St. Lawrence. Thomas C. Keefer.

Alois von Negrelli, Vol. 1. Alfred Birk.

Philosophy of Railroads. Thomas C. Keefer.

(Above five items gift of Clemens Herschel.)

International Engineering Congress, 1915: Transactions, 2 vols.: Electrical Engineering and Hydro-electric Power Development; Municipal Engineering.

Case against Municipal Ownership. F. G. R. Gordon.

Rensselaer Polytechnic Institute: Electrical Resistances and Temperature Coefficients of Nickel-Copper-Chromium Alloys. Frederick M. Sebast.

Wood-using Industries of Indiana. J. C. Nellis.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the first of each month.)

**Commonwealth of Massachusetts.**—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.*

*Sudbury Power Plant.* — The work of installing the hydro-electric machinery at the Sudbury Dam in Southboro is in progress.

*Sewerage Works.* — Work is in progress on Sections 103 and 104, Wellesley extension; and on the Malden River Siphon. The contract for the Deer Island extension of the outfall sewer has been let. Further work on the Wellesley extension sewer is contemplated.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Alewife Brook Parkway.* — Surfacing and finishing Alewife Brook Parkway, from Massachusetts Ave. to Powder House Boulevard. Kelley & Sullivan, contractors.

*Charles River Reservation.* — Building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown. A. G. Tomasello, contractor.

The construction of a reinforced concrete bridge over the Charles River at Commonwealth Ave., Newton and Weston, will be begun soon.

Work of excavating channel of Charles River from Elm St. to Bleachery Dam, Waltham, is in progress. John R. Burke, contractor.

*Furnace Brook Parkway.* — The construction of parkway extension from Quincy Shore Reservation to Hancock St. John Cashman & Sons Company, contractors.

Building reinforced concrete girder bridge across Blacks Creek, for Furnace Brook Parkway Extension. Hugh Nawn Contracting Company, contractors.

*Mystic Valley Parkway.* — Excavation of the channel of Aberjona River from Boston & Maine Railroad Bridge to Waterfield St., Winchester. Coleman Brothers, contractors.

*Old Colony Parkway.* — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

DIRECTORS OF THE PORT OF BOSTON. — *Reclamation of State Flats at East Boston.* — Under the contract with the Bay State Dredging and Contracting Company, further progress has been made in the construction of the 2 200 lin. ft. of bulkhead and filling adjacent thereto. The contract for rehandling 1 000 000 cu. yds. of material and depositing the same on flats east of Jeffries Point to reclaim 35 acres was awarded to the Atlantic, Gulf & Pacific Company on March 14, 1916. Pile ranges showing the limit of this work have been placed and active dredging is expected to commence at an early date.

*Dry-Dock at South Boston.* — Further progress has been made in the work at the dry-dock under the contract with the Holbrook, Cabot & Rollins Corporation. The dredging over the dry-dock site has been completed, with a total of about 290 000 cu. yds. removed.

The cofferdam being built across the open end of the site consists of two rows of 6-in. sheeting, eight feet apart, and double rows of piles. The space between the sheeting will be filled with clay, and embankments placed on both sides of the sheeting. When completed, this cofferdam will permit of unwatering the site and the excavation in the dry of the earth and rock for the dock walls and floor.

The contractor has continued the assembly of plant, the erection of cableway towers, and of materials for the dry-dock.

*Extension of Northern Avenue.* — Bids were received by the Directors on April 14, 1916, for the construction of 1 000 lin. ft. of timber bulkhead for the extension of Northern Ave. from its present terminus near the fish pier toward the dry-dock. The lowest bid was that of William H. Ellis & Son Co., which was $23.61 per lin. ft. of bulkhead, and the contract was awarded to him on April 17, 1916. The area enclosed by this bulkhead will be filled with cinders and ashes and other material suitable as a foundation for the roadway.

*Sewer in Fargo Street.* — Further progress has been made in the contract for construction of the sewer in Fargo St. between C and D Sts., to connect with the sewer of the city of Boston at C St.

*Tide Gage.* — An automatic tide gage has been purchased and installed by the Directors at Commonwealth Pier 5, South Boston, to maintain a systematic record of tidal fluctuations. This gage is of the 8-day type and arranged to record a tidal fluctuation of 20 ft. upon a chart having graduations of one-half inch per foot of tidal fluctuation, and one-half inch for each hour of time. It is expected that this gage will furnish valuable information not only to shippers but in all engineering work connected with the harbor improvements.

*Wollaston Yacht Club Channel.* — The dredging of the channel to the Wollaston Yacht Club has continued, and to date about 70 000 cu. yds. of material have been removed. This channel will have a width of 70 ft. and a depth of 8 ft. when completed.

*Neponset River Dredging.* — The work under a contract with the Gerrish Dredging Company for dredging about 35 000 cu. yds. of material from the Neponset River near Milton Lower Mills was begun on April 18, 1916. The depth to be obtained is 6 ft. at mean low water.

**Boston Transit Commission.** — *Dorchester Tunnel.* — Descriptions of Sections D, E, G and H were printed in the JOURNAL in October and December, 1915.

In Section E both shields are under the channel, the one for the easterly tunnel being within about 300 ft. and the one for the westerly tunnel within about 600 ft. of the northerly end of the section, where they will meet the completed tunnel at the easterly end of Section D under Summer St. About four fifths of the construction of Section E is done.

Section F includes a two-story underground station in Dorchester Ave., between Broadway and West Fourth St. The lower level is for the Dorchester Ave. trains, and the upper level for surface cars which will enter and leave by inclines, one in Dorchester Ave. just south of West Fourth St., and the other opening in Foundry St. between Broadway Extension and Dorchester Ave. This combined station for trains and surface cars allows passengers to transfer by means of stairs from one level to the other underground. The T. A. Gillespie Co. is the contractor for this section, and work is now in progress.

On Section G the sewer changes are being made. The construction of the tunnel structure in open cut between West Fourth and B Sts. in Dorchester Ave. is in progress.

The contract for the construction of Section J of the Dorchester Tunnel, which is located in and near Dorchester Ave. and Boston St., and includes the Andrew Square Station, has been awarded to The T. A. Gillespie Company, and work has been started near Dexter St.

**City of Boston.** — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

| | | |
|---|---|---|
| Dunlap St., | Washington St. to Whitfield St. | Asphalt. |
| Jones Ave., | Mascot St. to Ballou Ave. | Asphalt. |
| Kittredge St., | Cornell St. to Beech St. | Bitulithic. |
| Public Alley No. 903, | Haviland St. to Public Alley No. 904. | Hassam block |
| Public Alley No. 904, | Bickerstaff St. to Public Alley No. 903. | Hassam block. |
| Rosewood St., | Oakland St. to Randolph St. | Asphalt. |
| Spring St. (fence) at West Dept., City Hospital. | | ..... |
| Sturtevant St., | Park St. to Gibson St. | Hassam block. |
| Wachusett St., | Weld Hill St. to Barlou St. | Excavating and grading. |

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Seventeen submarine boats for U. S. Navy.
One submarine for Spanish Navy.
One oil tanker for Argentine Government.
Two torpedo boat destroyers, Nos. 63 and 64.
Four oil boats for the Texas Co.
Three molasses steamers for the Cuba Distilling Co.
Five freight steamers for the Luckenbach Co., Inc.
Two steel tank steamships for the Petroleum Products Co.

Vol. III JUNE, 1916 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY AFTERNOON, JUNE 21, 1916,

at the Pemberton Inn, Hull, Mass.

The meeting will be called to order at the close of the shore dinner, which will be served in connection with the Joint Field Day and Excursion of the New England Water Works Association and this Society. It is expected that Rear Admiral Robert E. Peary will address the Society on "National Preparedness."

S. E. TINKHAM, *Secretary.*

## PAPERS IN THIS NUMBER.

"The Yale Bowl," T. C. Atwood.

"Mosquito Extermination in Panama and New Jersey," H. I. Eaton.

"Reform and Regulation," A. C. Humphreys.

Discussion of "Power Estimates from Stream Flow and Rainfall Data."

Memoir of Deceased Member.

### CURRENT DISCUSSIONS.

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "Pan-American Use of Metric System." | F. Brooks. | Feb. | Aug. 10. |
| "Spillways of the Panama Canal." | E. C. Sherman. | April. | Aug. 10. |

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "Latest Method of Sewage Disposal." | E. Barton. | April. | Aug. 10. |
| "Service for the Society." | E. M. Blake. | April. | Aug. 10. |
| "Dorchester Tunnel." | A. A. Cohill. | May. | Aug. 10. |
| "Cambridge, Ohio, Water Works." | W. J. Sherman. | May. | Aug. 10. |



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

## MINUTES OF MEETINGS.

Boston, Mass., April 27, 1916. — A special meeting of the Boston Society of Civil Engineers was held this evening in the Society's Rooms, and was called to order at 8 o'clock by the President, Richard A. Hale. Thirteen members and visitors were present.

The subject for discussion as announced in the notice of the meeting was, "Practical Steps Remaining to be Taken in Completing the Abandonment of Ancient, Customary Units by the Substitution of the Metric System of Weights and Measures."

The discussion was opened by Past President Frederick Brooks, who was followed by Robert Spurr Weston, Alfred W. Parker, Edward P. Adams and others.

At 10.20 the meeting adjourned.

S. E. Tinkham, *Secretary.*

Boston, Mass., May 17, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the President, Richard A. Hale. There were 60 members and visitors present.

By vote, the record of the April meeting was approved as printed in the May Journal, and that of the special meeting held on April 27 was, after reading by the Secretary, also approved.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Guy Herbert Chase, Henry Emery Holmes and Ernest Elwell Lothrop.

Juniors — Frank Rundlett Coburn, Thomas Ewing Hannah and Leo Joseph Nawn.

The Secretary also reported for the Board of Government that an invitation had been received for the Society to participate in the Preparedness Parade, to be held in Boston on May 27, 1916, and the recommendation of the Board that the Society take part in the parade and the President be authorized to appoint a committee to have charge of the matter. On motion of Mr. Fay, the recommendation was adopted by a unanimous vote.

The President has appointed the following as members of that committee: Charles R. Gow, chairman; Frank M. Gunby, Richard K. Hale, Christopher Harrison and Edmund M. Blake.

The Secretary announced the deaths of Mr. Charles W. Ross, a member of the Sanitary Section, which occurred on April 11, 1916, and Dr. Elmer L. Corthell, a member of this Society and president of the American Society of Civil Engineers, which occurred on May 16, 1916.

By vote, the President was authorized to appoint committees to prepare memorials.

The Secretary presented the memoir on our late associate, Erasmus Darwin Leavitt, an honorary member of the Society, prepared by a committee consisting of Charles T. Main and Will J. Sando. By vote, the memoir was accepted and ordered printed in the JOURNAL.

Mr. Thomas C. Atwood then read the paper of the evening, entitled, " The Construction of the Yale Bowl." The paper was illustrated by a large number of lantern slides. At the conclusion of the reading of the paper, Mr. Atwood very kindly answered numerous questions which were asked in relation to the construction of the Bowl.

Adjourned.

S. E. TINKHAM, *Secretary*.

Boston, Mass., April 5, 1916. — A meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society Library, Tremont Temple. There were 18 members who met informally at Marston's restaurant for dinner before the meeting.

The meeting was opened by Chairman Frederic Bonnet, Jr., at 7.25 P.M.

The minutes of the March annual meeting were read and approved.

A preliminary report of the Committee on "Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water" was presented by the chairman, Wm. S. Johnson. Discussions of the subject were presented by Messrs. Dwight Porter, Otis F. Clapp, J. Leslie Woodfall, Harrison P. Eddy, Edgar S. Dorr, Lewis M. Hastings, Bertram Brewer, Frederic A. Caldwell, Henry A. Varney and Laurence B. Manley.

It was evident that the committee had gathered a large amount of data concerning inverted siphons, and the final report of the committee when presented should be a valuable addition to engineering literature.

There were 54 present at the meeting. The meeting adjourned at 10 o'clock.

Frank A. Marston, *Clerk.*

Boston, Mass., May 3, 1916. — A meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in the Society Library, Tremont Temple.

The meeting was opened by Chairman Frederic Bonnet, Jr., at 7.25 o'clock. The minutes of the April meeting were read and approved.

The Clerk announced that, by vote of the Executive Committee, in accordance with authority of the Section (vote of March 1, 1916), the following have been appointed as a committee on Sewer Assessments:

Wm. S. Johnson, *Chairman.*
H. P. Eddy.
F. A. Barbour.
W. P. Morse.
E. Worthington.
E. S. Larned.

The speaker of the evening, Mr. Arthur R. Keller, professor of civil engineering in the Hawaiian College, gave a very interesting and entertaining talk on "Sanitary and Hydraulic Work in the Hawaiian Islands." Mr. Keller has had an exceptional opportunity to study sanitary conditions and works of this character, because of his membership in the Territorial Board of Health, of which he has been president. The talk was illustrated by about one hundred and twenty-five lantern slides, some of which were colored. Not only did he describe sanitary and hydraulic work, but also some details of the sugar industry and other features of popular interest in connection with the Hawaiian Islands.

It was voted to extend to Mr. Keller a rising vote of thanks for his courtesy in presenting the paper of the evening.

There were 37 present, and the meeting adjourned at 9.40 o'clock.

FRANK A. MARSTON, *Clerk.*

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## APPLICATIONS FOR MEMBERSHIP.

[June 8, 1916.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission, and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as references does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

FORD, ARTHUR LEON, Danvers, Mass. (Age 29, b. Savoy, Mass.) Graduate of Worcester Polytechnic Inst., 1911, civil engineering course. From February to August, 1910, draftsman with Ludlow Mfg. Associates, Ludlow; from July to November, 1911, rodman and transitman with Clapp & Abercrombie Co., Greenfield; from November, 1911, to September, 1912, junior partner and transitman with A. F. Brown, Greenfield; from September, 1912, to September, 1913, transitman and chief-of-party with Clapp & Abercrombie Co.; from September to December, 1913, transitman and inspector with Mass. Highway Comm.; from June, 1914, to date, transitman and resident engineer with Mass. Highway Comm. Refers to J. K. Barker, A. P. Rice, F. D. Sabin, G. P. Soutar and A. E. Tarbell.

KLINK, NASSIME SOLOMON, Boston, Mass. (Age 32, b. Mt. Lebanon Syria.) Student for two years at College National, Baabdat, Syria, 1895 to 1897; took correspondence course in civil engineering; graduate of Mass. Inst. of Technology, 1915, civil engineering course. In 1906, architectural draftsman with Joseph Robichau, Lawrence, Mass.; from 1907 to 1910, rodman and instrumentman with John Franklin, Lawrence; during college course and since graduation has practiced engineering and architecture in Boston and Lawrence; is now instrumentman with Fore River Shipbuilding Corp'n. Refers to C. F. Allen, C. B. Breed, Dwight Porter and C. M. Spofford.

SNOW, BENJAMIN HARRISON, Everett, Mass. (Age 23, b. Everett, Mass.) Received technical education at Evening Polytechnic School of Boston Y. M. C. A., completing surveying course in 1913 and four-year structural engineering course in 1916. From August, 1913, to April, 1914, and from August to October, 1914, transitman and inspector at new fish pier, South Boston; from April to August, 1914, transitman with Whitman & Howard, Boston; from October, 1914, to May, 1915, draftsman on ornamental iron and light structural steel with Babcock-Davis Corp'n, Cambridge; is now civil engineer with Industrial Service & Equipment Co., Boston. Refers to B. S. Brown, C. S. Ell, Channing Howard and T. E. Penard.

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## LIST OF MEMBERS.

ADDITIONS.

APPLETON, THOMAS A. .......... 237 Essex St., Salem, Mass.
CRAIGUE, JOSEPH S. .......... Town Hall, Walpole, Mass.
ELLSWORTH, SAMUEL M. .......... 117 Adams St., Braintree, Mass.
FARRELL, FRANCIS B. .......... 76 Francis St., Roxbury, Mass.
LOTHROP, ERNEST E. .......... 21 Allston Pl., Fitchburg, Mass.
TURNER, JOHN M. .......... 384 Washington St., Brookline, Mass.

CHANGES OF ADDRESS.

| | |
|---|---|
| Allen, John E. | 316 Huntington Ave., Boston, Mass. |
| Armstrong, Kenneth P. | 1512 Kearney St., N. E., Washington, D. C. |
| Blake, Edmund M. | 6 Beacon St., Boston, Mass. |
| Clapp, Frederick O. | 11 Bridgham St., Providence, R. I. |
| Clapp, Otis F. | 11 Bridgham St., Providence, R. I. |
| Dotten, Wm. J. | 14 Reservoir St., Winchester, Mass. |
| Duffy, J. Henry | 25 Maple St., Lexington, Mass. |
| Gallagher, John P. | 16 Hawthorne St., Watertown, Mass. |
| Gladding, Raymond D. | 662 Western St., West Lynn, Mass. |
| Harty, John J., Jr. | 78 Devonshire St., Boston, Mass. |
| Hunter, Robert C. | 51 Harbor View Ave., Winthrop, Mass. |
| Keith, Herbert C. | 154 Nassau St., New York, N. Y. |
| Lovis, Andrew M. | Rm. 212, State House, Boston, Mass. |
| Mead, Royal L. | 30 Hemenway St., Boston, Mass. |
| Newsom, Reeves J. | 84 Eastern Ave., East Lynn, Mass. |
| Savage, J. Dana | 258 Park Pl., Woonsocket, R. I. |
| Smith, Edward R. | River John, Pictou Co., Nova Scotia |
| Stone, George C. | Hurt, Va. |
| Stradling, David W. | 131 Ingalls Bldg., Cincinnati, Ohio |
| Treadwell, Edward D. | 101 Linden Ave., Malden, Mass. |
| van Rensselaer, Allen | 718 Petaluma Ave., San Rafael, Calif. |
| Wolfe, Christian F. | 525 58th St., Brooklyn, N. Y. |

DEATH.

| | |
|---|---|
| Corthell, Elmer L. | May 16, 1916 |

## EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### Men Available.

359. Age 48. Received technical education at Mass. Inst. of Technology. Has had wide experience in all branches of municipal engineering, including sewerage, water-supply protection, etc.; experience also includes

highway engineering and grade-crossing elimination. Will accept position at moderate salary.

360. Age 32. High school graduate; student for one year at Franklin Union. Experience includes three years with engineering firm in Massachusetts; one year on irrigation work in Colorado; eight months as assistant superintendent on Shoshone Dam, Cody, Wyo.; five years as assistant engineer on railroad construction in Panama for United Fruit Co.; six months as chief engineer on construction of small railroad in Nicaragua; and six months as instrumentman and inspector on New York Subway. Desires position as superintendent on concrete construction or as inspector of masonry. Salary desired, $25 per week, with prospect of advancement.

361. Age 52. Has had twenty-five years' experience, including water and sewer construction, permanent road construction of all kinds, underground construction for telephone and electric lights, and heavy reinforced concrete construction for bridge work, culverts and buildings. Salary desired, $100 per month.

362. Age 30. Passed examination for supervisor, Water State of Holland, 1908. Experience includes five and one-half years as supervisor and draftsman on building and bridge construction in Holland; one year in Belgium as inspector, testing materials for Technic Bureau of Colonies in Holland; and more than three years as rodman, draftsman and asst. engineer in Canadian and western cities. Salary desired, $75 per month.

363. Age 23. Graduate of Mechanic Arts High School; student at Tufts College Engineering School, class of 1916. Has had ten months' experience on building and dam construction. Desires position as rodman, transitman or timekeeper. Salary desired, $60 per month.

364. Age 25. Fourth-year student at Mass. Inst. of Technology, civil engineering course. Experience consists of two years' and four summers' work as timekeeper and general assistant in office of firm of builders in Brooklyn, N. Y. Desires position with contractor. Salary desired, $60 per month.

## LIBRARY NOTES.

### Recent Additions to the Library.

**U. S. Government Reports.**

Analyses of Coal Samples from Various Parts of United States. Marius R. Campbell and Frank R. Clark.

Atlantic Gold District and North Laramie Mountains, Fremont, Converse, and Albany Counties, Wyoming. Arthur C. Spencer.

Forest Conservation for States in Southern Pine Region. J. Girvin Peters.

Results of Observations made at United States Coast and Geodetic Survey Magnetic Observatory near Tucson, Arizona, 1913 and 1914. Daniel L. Hazard.

**State Reports.**

Massachusetts. Annual Report of Directors of Port of Boston for 1915.

Massachusetts. Annual Report of Gas and Electric Light Commissioners for 1914–15.

Massachusetts. Report of State Board of Health relative to Disposal of Sewage in South Metropolitan Sewerage District and to Extension of Limits of District, 1914.

Massachusetts. Report of State Department of Health on Protection of Public Health in Valley of Neponset River, 1916.

Michigan. Annual Report of State Board of Health for 1913–14.

Wisconsin. Physical Geography of Wisconsin. Lawrence Martin.

**Municipal Reports.**

Concord, N. H. Annual Report of Water Commissioners for 1915.

Fitchburg, Mass. Annual Report of Water Commissioners for 1915.

Fitchburg, Mass. Semi-Annual Reports of Sewage Disposal Commission for 1915.

Holyoke, Mass. Annual Report of Water Commissioners for 1915.

Medford, Mass. Annual Report of Water and Sewer Commissioners for 1915.

New Bedford, Mass. Annual Report of Engineering Department for 1915.

Taunton, Mass. Annual Report of Water Board for 1915.

Ware, Mass. Annual Report of Water Commissioners for 1915.

Wilmington, Del. Report on New Castle County Highways. Arthur H. Blanchard, Henry G. Shirley and George W. Tillson.

Worcester, Mass. Annual Report of Superintendent of Sewers for 1915.

Worcester, Mass. Annual Report of Water Commissioner for 1915.

**Miscellaneous.**

International Engineering Congress, 1915: Transactions: Naval Architecture and Marine Engineering.

New International Encyclopædia, Vols. 19 and 20.

LIBRARY COMMITTEE.

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## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

**Commonwealth of Massachusetts.**—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.*

*Sudbury Hydro-Electric Power Plant.* — The electrical machinery is being installed at the Sudbury Dam in Southborough.

*Sewerage Works.* — Work is in progress on Sects. 103 and 104, the Wellesley extension sewer; and on Sect. 1A, the outfall sewer at Deer Island. Sect. 19, the Malden River Siphon, is completed.

Work contemplated consists of Sects. 98 and 99, Wellesley Extension Sewer, which are under contract; and the extension of Sect. 1, Deer Island outfall.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Alewife Brook Parkway.* — Surfacing and finishing Alewife Brook Parkway, from Massachusetts Ave. to Powder House Boulevard. Kelley & Sullivan, contractors.

*Charles River Reservation.* — Reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown. A. G. Tomasello, contractor. Reinforced concrete bridge over the Charles River at Commonwealth Ave., Newton and Weston. T. Stuart & Son Company, contractor. Excavating channel of Charles River from Elm St. to Bleachery Dam, Waltham. John R. Burke, contractor.

*Furnace Brook Parkway.* — Parkway extension from Quincy Shore Reservation to Hancock St. John Cashman & Sons Company, contractor.

*Mystic Valley Parkway.* — Channel of Aberjona River from Boston & Maine Railroad Bridge to Waterfield St. Coleman Brothers, contractors.

*Old Colony Parkway.* — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

*General.* — The work of repairing road surfaces in all divisions is in progress.

Directors of the Port of Boston. — *South Boston Dry Dock.* — Under the contract with the Holbrook, Cabot & Rollins Corp'n, for the construction of the Dry Dock, further progress has been made in the assembly of materials and plant and the construction of railroad tracks. The cofferdam is nearing completion and a boiler plant and pump for unwatering the dry-dock site are being installed. The total amount of dredging to date at the turning basin near the main ship channel is about 350 000 cu. yds.

*Extension of Northern Avenue.* — The W. H. Ellis & Son Co., the contractor for the construction of about 1 000 ft. of timber bulkhead for the extension of Northern Ave., began the driving of piles for this work on May 20, 1916.

*Sewer in Fargo Street.* — The contract with J. H. Ferguson for the construction of a sewer in Fargo St. between C and D Sts., to connect with the city sewer in C St., has been completed.

*Reclamation of Flats at East Boston.* — Under the contract with the Bay State Dredging & Contracting Co., for the construction of timber and bulkhead extending easterly from Jeffries

Point, about 1 000 ft. of bulkhead has been completed and about 75 000 cu. yds. of dredging and filling has been done.

*Rehandling Plant.* — Work has been begun under the contract with the Atlantic, Gulf & Pacific Co. for the rehandling of about 1 000 000 cu. yds. of material for the reclamation of about 35 acres of state flats at East Boston, east of Jeffries Point. The dredge used is the *Pittsburg*, one of the largest of its kind, a hydraulic suction dredge having suction and discharge pipes each 27 ins. in diameter. The portion of the work started upon is the construction of the earth dikes along the easterly side of the area to be reclaimed.

*Mystic River Dredging.* — The Maryland Dredging Co., having a contract for removing about 500 000 cu. yds. of material from Mystic River above the Chelsea Bridge, has dredged to date about 120 000 cu. yds. The dipper dredge *Governor Warfield* is employed on this work. The dredged material has been deposited largely at East Boston within the area designated as the receiving basin, east of the anchorage basin, for rehandling under another contract for the reclamation of state flats.

*Neponset River Dredging.* — Under contract with the Gerrish Dredging Co. for removing about 35 000 cu. yds. of material from Neponset River at Milton, near Milton Lower Mills, work was started on April 17, 1916. The hydraulic dredge *Middlesex* is employed on this work, and is pumping this material upon a marsh area north of the area being dredged. The depth of water to be secured is 6 ft. at mean low water.

*Wollaston Yacht Club.* — The Morris & Cumings Dredging Co. has continued dredging at Wollaston. The depth to be secured is 8 ft. at mean low water for a width of 70 ft.

**Boston Transit Commission.** — *Dorchester Tunnel.* — Descriptions of Sections D, E, G and H were printed in the JOURNAL in October and December, 1915.

The work on the finish of South Station Under is nearing completion. It consists of setting doors, hand-rails, fences, etc., installing escalators, and rubbing down and polishing the concrete coverings over the stairways and escalators.

In Section E, the easterly tunnel has encountered the advance pilot drift which extends about 70 ft. east of the completed work in Summer St., and the shield is within a few feet of its final position, where the decks and inside framing will be removed and the shell left in the tunnel lining. The shield of the westerly or southbound tunnel is within 300 ft. of the end of the completed work in Summer St.

Section F was described in the May JOURNAL. Work is now in progress underpinning the buildings adjacent to the work and putting in the sidewalls of the tunnel station.

On Section G the construction of the tunnel structure in open cut between West Fourth and B Sts., in Dorchester Ave., is in progress.

Section J was also described in the May JOURNAL. Work has been started near Dexter St. and in Andrew Sq., and the excavation near Dexter St. is nearly to grade.

**City of Boston.** — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

| | | |
|---|---|---|
| Gladstone St., | from Walley St. to Upland Ave. | Artificial stone walks. |
| Washington St., | from Tip Top St. to the Newton line. | Artificial stone walks. |
| Glendower Rd., | from Kittredge St. to Poplar St. | Asphalt pavement. |
| Kittredge St., | from Cornell St. to Beech St. | Asphalt pavement. |
| Poplar St., | from Sycamore St. to Brown Ave. | Artificial stone walks. |
| Poplar St., | from Washington St. to Sycamore St. | Artificial stone walks. |
| Wachusett St., | from Weld Hill St. to Barlow St | Excavating and grading. |
| Montebello Rd., | from Forest Hills St. to Walnut Ave. | Bitulithic pavement. |
| Jones Ave., | from Mascot St. to Ballou Ave. | Asphalt pavement. |
| Rosewood St., | from Oakland St. to Randolph Rd. | Asphalt pavement. |
| Sturtevant St., | from Park St. to Gibson St. | Hassam block pavement. |
| Fernboro St., | from Lawrence Ave. to Intervale St. | Asphalt pavement. |
| Public Alley No. 903, | from Haviland St. to Public Alley No. 904. | Hassam block pavement. |
| Public Alley No. 904, | from Bickerstaff St. to Public Alley No. 903. | Hassam block pavement. |
| Saratoga St., | from Butler Ave. to Washburn Ave. | Artificial stone walks. |

**Boston Elevated Railway Company.** — BUREAU OF ELEVATED AND SUBWAY CONSTRUCTION. —

*Dudley St. Station.* — In compliance with orders issued by the Public Service Commission, the pavilion on the East elevated loop, containing waiting-room, toilets, news booth, boot-black and barber shop, has been removed. The double stopping of cars will be discontinued, a single stop being substituted, unloading and loading to occur simultaneously. An illuminated destination sign, similar to the one so successfully operated at the Park St. subway station, will be at once installed. At the lower level, an elevated column has been removed to permit the installation of a turnout from the outbound Warren St. surface track to the westbound track in the surface prepayment area. These changes, together with the inauguration of a prepayment surface area at Egleston Sq., will, it is felt, relieve the congested traffic conditions at Dudley St. for many years to come.

*Everett Extension.* — Work by the Hugh Nawn Contracting Co. is progressing on the contract for the foundations for the Mystic River Bridge and Viaduct and the Malden Bridge changes. The contract for the superstructure, including the 95-ft. span, double-track, deck-plate girder, Strauss trunnion bascule bridge, and the 102-ft. span, pony truss, highway Strauss trunnion bascule bridge, is about to be let. This contract embraces the entire electrical and mechanical equipment, together with the erection and complete installation.

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Torpedo-boat destroyers *Sampson* and *Rowan*, U. S. Government.

Cargo vessel *Cubadist*, Cuba Distilling Co.
Molasses steamer *Sucrosa*, Cuba Distilling Co.
Molasses steamer *Mielero*, Cuba Distilling Co.
Two freight steamers, Texas Co.
Tank steamer, Argentine Government.
Freight steamer *K. I. Luckenbach*, Luckenbach Co., Inc.
Freight steamer *F. J. Luckenbach*, Luckenbach Co., Inc.
Freight steamer, Luckenbach Co., Inc.
Tank steamers, two, Petroleum Transport Co.
Eleven submarines for U. S. Government.
One submarine for the Spanish Government.

Vol. III SEPTEMBER, 1916 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, SEPTEMBER 20, 1916,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Eugene E. Pettee will present a paper entitled, "The Construction of the Portland Bridge." The paper will be illustrated with lantern slides.

S. E. TINKHAM, *Secretary.*

## PAPERS IN THIS NUMBER.

"The Commercial Fertilizer Industry in the United States," Lester W. Tucker.

"The Sewage Disposal Problem Confronting the City of Philadelphia," W. L. Stevenson.

"A Method of Transforming Latitude and Longitude into Plane Coördinates," S. H. Thorndike.

Discussion of "Pan-American Use of the Metric System."

Discussion of "Reform and Regulation."



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

## PREPAREDNESS PARADE,

May 27, 1916.

The Boston Society of Civil Engineers was represented in the Preparedness Parade by about sixty members, forming two companies of two platoons each, led by a marshal and staff officers. Many members of the Society marched in other sections of the engineers' division.

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## MINUTES OF MEETING.

Hull, Mass., June 21, 1916.— A regular meeting of the Boston Society of Civil Engineers was held this afternoon at the Pemberton Inn at the close of the shore dinner which was served in connection with the Joint Field Day and Excursion of the New England Water Works Association and this Society.

The meeting was called to order by the President, Richard A. Hale, at 3 o'clock. There were present 193 members and guests, including members of the Water Works Association and ladies.

By vote, the record of the May meeting was approved as printed in the June Journal.

The President announced the election by the Board of Government of Mr. John P. Cyr as a member of the Society.

Prof. Alfred E. Burton brought to the attention of the meeting, the work of the Committee to Expedite the Completion of the Topographic Map of the United States. He stated that although the appropriations made by Congress have been liberal, and although topographic mapping has been industriously prosecuted by the United States Geological Survey for the past thirty-five years, so great is our national domain, that up to last July only 40 per cent. of its area had been represented on published maps, and at that rate of progress, about one hundred years will be needed to complete the map. He urged all who are interested in the matter to write to the Director of the United States Geological Survey, stating the practical uses that they make of the published maps and the value that they attach to them.*

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* See further statement by Professor Burton printed in this number of the Journal.

The President then introduced Rear-Admiral Robert E. Peary, who addressed the Society on National Preparedness.

After passing a vote of thanks to Admiral Peary for the interesting and instructive address which he had given, the Society adjourned.

S. E. Tinkham, *Secretary.*

Boston, Mass., June 7, 1916. — The regular June meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society Library, Tremont Temple.

The meeting was opened at 7.45 o'clock with Chairman Frederic Bonnet, Jr., presiding. The minutes of the May meeting were read and approved.

The chairman then introduced Mr. W. L. Stevenson, assistant engineer in charge, Sewage Disposal, Philadelphia, Pa., who presented a paper on "The Sewage Disposal Problem Confronting the City of Philadelphia." Mr. Stevenson described briefly, with the aid of lantern slides, the plan adopted for the collection, treatment and disposal of the sewage of the city at three main disposal works. He also described in considerable detail the design and form of construction of the Frankford Creek Intercepting Sewer. Many details were discussed which were of particular interest to members present who have to design sewerage works and, especially, regulating devices. Considerable interest was shown by all, and, taking all matters into consideration, the meeting proved to be one of the best held for some time.

It was voted to extend a rising vote of thanks to Mr. Stevenson for his courtesy in presenting the paper and explaining so many details.

There were 46 present. Adjourned at 9.25 o'clock.

Frank A. Marston, *Clerk.*

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## APPLICATIONS FOR MEMBERSHIP.

[September 5, 1916.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Bell, Frank Charles, Malden, Mass. (Age 42, b. Somerville, Mass.) Educated in public schools; graduate of Malden High School, 1892. From 1892 to 1898, with late W. H. Whitney, Boston, on municipal surveying; from 1898 to date, with Boston Elevated Ry. Co.; is now assistant engineer, department of Maintenance of Way. Refers to L. S. Cowles, B. W. Ellis, H. C. Hartwell and A. L. Plimpton.

Delano, Ray Osborn, Boston, Mass. (Age 23, b. North Duxbury, Mass.) Student at Mass. Inst. of Technology for three years; graduate of Lowell Inst. School for Industrial Foremen, 1916, buildings course. Refers to H. W. Hayward, G. L. Hosmer, W. H. Lawrence and A. G. Robbins.

Wade, Wm. Newell, Boston, Mass. (Age 45, b. Easton, Mass.) Graduate of North Easton High School, 1888. From Nov., 1888, to April, 1892, on land survey; from April to July, 1892, on street railway location; from July to Nov., 1892, with the City of Brockton on sewerage system; from Nov., 1892, to July, 1893, with B. & M. R. R., on track locations; from July, 1893, to July, 1900, assistant to roadmaster with N. Y., N. H. & H. R. R., Maintenance of Way Dept.; from Aug., 1900, to April, 1901, with Boston Elevated Ry. Co., as steel inspector on elevated construction; from April, 1901, to July, 1915, assistant engineer with Mass. Highway Commission; from July, 1915, to Feb., 1916, first assistant engineer with Coleman du Pont Road, Inc., Georgetown, Del.; from April, 1916, to date, with Mass. Highway Commission. Refers to A. B. Appleton, C. L. Brown, A. W. Dean, A. M. Lovis, F. H. Morris and C. H. Restall.

Young, Erving Mandeville, Waterbury, Conn. (Age 27, b. Haverhill, Mass.) Graduate of Mass. Inst. of Technology, 1911, civil engineering course. Since that time has been engaged chiefly in inspection of concrete and heavy timber construction for Monks & Johnson, Stone & Webster Engrg. Corp'n and Aberthaw Construction Co.; was employed by last-named company as efficiency and cost expert on ten concrete buildings for Winchester Arms Co., New Haven, Conn., and two for Pierce Arrow Motor Co. at Buffalo, N. Y.; was in charge of inspection for Stone & Webster on one half of new Technology buildings; is now engineer in charge of outside construction of concrete building for Chase Metal Works, Waterville, Conn. Refers to L. H. Allen, J. A. Garrod, Mark Linenthal, C. G. Richmond and C. M. Spofford.

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## LIST OF MEMBERS.

### ADDITIONS.

Coburn, Frank R. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Watertown, Mass.
Cyr, John P. . . . . . . . . . . . . . . . . . . . . . . . . . . 10 Hartshorn Ave., Nashua, N. H.
Hannah, Thomas E. . . . . . . . . . . . . . . . . . . . 70 Congress St., Fitchburg, Mass.
Holmes, Harry E. . . . . . . . . . . . . . . . . . . . . . . . 115 Walnut St., Malden, Mass.

### CHANGES OF ADDRESS.

Albee, Edward E. . . . . . . . . . . . . . . . . . . . . . 24 Prospect St., Weymouth, Mass.
Bigelow, William W. . . . . . . . . . . . . . . . . . . . . 624 State St., Springfield, Mass.
Cashman, John M. . . . . . . . . . . . . . . . . . 60 Beechwood Ave., Watertown, Mass.
Cowles, M. Warren . . . . . . . . . . . . . . . . . 426 W. Munroe St., Springfield, Ill.
Cross, Ralph U. . . . . . . . . . . . . . . . . . . . . . 130 Burncoat St., Worcester, Mass.
Curtis, Allen . . . . . . . . . . . . . . . . . . . 21 Lexington Ave., W. Somerville, Mass.
De La Haye, Elias, Jr. . . . . . . . . . . . . . . . . 25 Glendale St., Dorchester, Mass.
Fehr, Gordon . . . . . . . . . . . . . . . . . . . . . . . . 5704 Baum Blvd., Pittsburgh, Pa.
Flaws, James B. . . . . . . . . . . . . . . . . . 3 Newbridge Ave., North Woburn, Mass.
Foster, Howard L. . . . . . . . . . . . . . . . . . . 102 Huntington Ave., Boston, Mass.
Green, Howard W. . . . . . . . . . . . . . . . . 383 South Main St., Woonsocket, R. I.
Hayward, Edwin D.,
Dept. of Civil Engrg., University of California, Berkeley, Cal.
Morrison, Harry J. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Mullens, W. Va.
Nolan, Conrad . . . . . . . . . . . . . . . . . . . . . . 2 Curtis Ave., Tufts College, Mass.
Peacock, Frank E. . . . . . . . . . . . . . . . . . . . . 623 N. Church St., Rockford, Ill.
Pettee, Eugene E. . . . . . . . . . . . . . . . . . . . . . . . . . 79 Milk St., Boston, Mass.
Powers, William J., Jr. . . . . . . . . . . . . 130 Mt. Pleasant Ave., Roxbury, Mass.
Reilly, L. Bayles . . . . . . . . . . . . . . . . . . . 602 City Hall Annex, Boston, Mass.
Simons, George W., Jr. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Jacksonville, Fla.
Snow, Leslie W. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Rochester, N. H.
Wires, Harrison P. . . . . . . . . . . . . . . . . . . . . . 47 Broadway, Rockport, Mass.
Wolfe, Christian F. . . . . . Y. M. C. A., 404 East 10th St., Kansas City, Mo.

## EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### Men Available.

No. 365. Age 22. Student for three years in engineering department, Tufts College. Has had one year's experience as timekeeper and foreman on concrete work. Salary desired, $10 per week.

No. 367. Age 19. Student for one year at Harvard University. Has had no practical experience. Desires to start in office or with party in field.

No. 370. Age 30. Educated in public schools, including high school. Experience consists of nine years with consulting engineers, during which time he has served in various capacities, from office boy to resident engineer; work has been chiefly on water works and sewerage. Desires position with contractor or field work with engineer.

No. 371. Age 32. Received education at technical and evening schools. Has had fourteen years' experience, including three years with railroad corporation, two as draftsman in Bridge Dept. and one as rodman and transitman in Construction Dept.; five years with private engineering and contracting concerns as draftsman, designer and estimator on structural steel and concrete work; and six years with large corporation as draftsman and assistant engineer in charge of designs for storehouses, rendering plants, etc. Desires position with live engineering firm as assistant engineer, or with a contracting firm as engineer and estimator. Salary desired, $2 500 per year.

No. 372. Age 20. Educated in public and private schools, including high school. Is without experience, but is good at lettering. Desires work as tracer, preferably with architect.

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## COMPLETION OF THE TOPOGRAPHIC MAP OF THE UNITED STATES.

Prof. Alfred E. Burton, Secretary of the Committee to Expedite the Completion of the Topographic Map of the United

States, has submitted the following statement in relation to the completion of the map:

A committee made up of prominent civil and hydraulic engineers, foresters, highway commissioners and business men, has been organized with the intention of urging the speedy completion of a topographical map of the United States. They are sending out a circular to all engineers who they think would be interested in this project, and are inviting them to write to the secretary of their committee a letter which the committee can be authorized to use later in making a statement of the case to the appropriate congressional committee. In their circular there is this statement in regard to the present state of the map:

A standard topographical map of the entire area of the United States based on official surveys has been in preparation by the United States Geological Survey since 1880, and although the survey has been industriously prosecuted, and although the appropriations made by Congress have been liberal, up to July 1, 1915, only 40 per cent. of our domain has been represented on published topographical maps. The rate of progress since 1905 has been very much slower, and the rate has been practically steady during the past ten years. If this rate is not accelerated, the whole country will not be surveyed for one hundred years.

Progress towards its completion must be expedited, especially for a belt of country several hundred miles inland from all our coasts and frontiers. For this, an annual increase in the appropriation for a topographical map should be made for five or ten years to come.

Various corporations, commissions and individuals are invited to state the practical uses that they make of the published maps, and the value that they attach to them, and to send a copy of their statements to the Director of the United States Geological Survey and to the secretary of this committee. Statements to the same effect will be requested from various interested organizations, such as engineering societies, state academies of science, geological and geographical societies, automobile and mountaineering clubs, etc. This committee will prepare a statement based on the testimony thus secured as to the practical value of the topographical maps now published, the need of maps in unsurveyed areas, the need of larger-scale maps for areas already published on a smaller scale, and the need of the revision of all maps with respect to new cultural features. This statement will then be submitted to the appropriate committee of Congress.

A partial list of the questions which the committee would like answered is appended:

Have you found the maps useful in railway engineering?
in highway engineering?
in forest surveys?
in irrigation projects?
in drainage projects?
in soil surveys?
in water-power projects?
in electrical transmission lines?
in prospecting in mining?
in publishing?
in teaching?

They would also like to have statements from individuals of specified examples of the manner in which published maps have aided their work, and how work might have been facilitated in unsurveyed regions if the maps had been available. They also invite criticism and would like to have it stated in what respects are the published maps insufficient for engineering needs. Is their scale too small; have they been found inaccurate?

Very truly yours,

ALFRED E. BURTON, *Secretary of the Committee.*

The following is the membership of the Committee to Expedite the Completion of the Topographical Map of the United States:

W. M. Davis, chairman, professor of geology, emeritus, Harvard University, Cambridge, Mass.; A. E. Burton, secretary, dean, Massachusetts Institute of Technology, Cambridge, Mass.; Robert Bacon, president National Security League, New York; Arthur H. Blanchard, consulting engineer National Highways Association, professor of highway engineering, Columbia University, New York; G. P. Coleman, state commissioner of highways, Richmond, Va.; G. E. Condra, president National Conservation Congress, State University, Lincoln, Neb.; W. L. Darling, chief engineer Northern

Pacific Railway Co., St. Paul, Minn.; R. E. Dodge, president National Council Geography Teachers, Teachers' College, New York; A. B. Fletcher, state highway engineer, Sacramento, Cal.; W. Cameron Forbes, of J. M. Forbes & Co., Boston, Mass.; John R. Freeman, consulting engineer, Providence, R. I.; W. O. Hotchkiss, state geologist, Madison, Wis.; F. H. Newell, professor of civil engineering, University of Illinois, Urbana, Ill.; Joseph H. Pratt, state geologist, Chapel Hill, N. C.; Wm. Barclay Parsons, consulting engineer, New York; Charles A. Stone, of Stone & Webster, Boston, president International Corporation, New York; Frank M. Williams, state engineer, Albany, N. Y.

## LIBRARY NOTES.

### Book Review.

The American Road, by James I. Tucker, professor of civil engineering, University of Oklahoma; for sale by The American Road, Norman, Okla., 1916. Cloth, 5 in. by 7 in., 235 pages, 39 illustrations, 15 tables. $1.08.

*Reviewed by Arthur W. Dean.*

While, as the author states on the title-page, this is a "non-engineering manual for practical road builders," it nevertheless contains much matter of interest to the engineer, and of special value to the young graduate civil engineer, who has given little attention to matters most characteristic and vital in highway work. It presents, in clear and concise language, simple facts which are essential in road building. Fifteen chapters, covering 228 pages, describe in non-technical language the problems of the road builder, including, besides methods and materials, the economics, proper organization, the needed legislation and the many other major and minor matters constantly open for discussion by those interested in the subject.

In describing construction methods and materials, the author gives very general descriptions, giving considerable space to gravel and other cheap types of roads, but little direct information on more permanent types of roadways.

The book is quite valuable for the main purpose for which it was prepared, viz., to use in connection with correspondence instruction, in which use it will tend to encourage study and thought on road construction.

## Recent Additions to the Library.

### U. S. Government Reports.

Abrasive Materials in 1915. Frank J. Katz.

Annual Report of Chief of Weather Bureau for 1914–15.

Automobile Registrations, Licenses, and Revenues in United States, 1915.

Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between 1910 and 1914. Bertrand L. Johnson.

Revision of Beckwith and Bear River Formations of Southeastern Idaho. G. R. Mansfield and P. V. Roundy.

Caddo Oil and Gas Field, Louisiana and Texas. George Charlton Matson.

Strength and Other Properties of Concretes as Affected by Materials and Methods of Preparation. R. J. Wig, G. M. Williams and E. R. Gates.

Cotton Production in United States, Crop of 1915.

Fauna of Chapman Sandstone of Maine. Henry Shaler Williams.

Feldspur in 1915. Frank J. Katz.

Flora of Fox Hills Sandstone. F. H. Knowlton.

Fluorspar in 1915. Ernest F. Burchard.

Arguments For and Against Limitation of Length of Freight Trains.

Fuller's Earth in 1915. Jefferson Middleton.

Contributions to Economic Geology, 1915. Part I. — Metals and Non-Metals except Fuels. F. L. Ransome and Hoyt S. Gale.

Geology and Coal Resources of Castle Valley, Utah. Charles T. Lupton.

Geology and Underground Water of Luna County, New Mexico. N. H. Darton.

Gold, Silver, Copper, Lead, and Zinc in Eastern States in 1915. James M. Hill.

Graphite in 1915. Edson S. Bastin.

Experiments on Economical Use of Irrigation Water in Idaho. Don H. Bark.

Determination of Difference in Longitude between Each

Two of Stations Washington, Cambridge, and Far Rockaway. Fremont Morse and O. B. French.

Results of Magnetic Observations Made by United States Coast and Geodetic Survey in 1915; Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1913 and 1914; Results of Observations Made at United States Coast and Geodetic Survey Magnetic Observatory at Vieques, Porto Rico, 1913 and 1914. Daniel L. Hazard.

Some Manganese Mines in Virginia and Maryland. D. F. Hewett.

Mineralogic Notes: Series 3. Waldemar T. Schaller.

Relation of Wissahickon Mica Gneiss to Shenandoah Limestone and Octoraro Schist of Doe Run and Avondale Region, Chester County, Pennsylvania. Eleanora F. Bliss and Anna I. Jonas.

National Parks Portfolio.

Ozokerite in Central Utah. Heath M. Robinson.

Physical Conditions and Age Indicated by Flora of Alum Bluff Formation. Edward Wilber Berry.

Physical Conditions Indicated by Flora of Calvert Formation. Edward Wilber Berry.

Portland Cement Materials and Industry in United States. Edwin C. Eckel.

Petroleum Withdrawals and Restorations Affecting Public Domain. Max W. Ball.

Experiments on Extraction of Potash from Wyomingite. Roger C. Wells.

Primary Traverse in Alabama and North Carolina, 1913–15. R. B. Marshall.

Railway Stockholders, June 30, 1915.

Results of Physical Tests of Road-building Rock. Prévost Hubbard and Frank H. Jackson, Jr.

Sand-lime Brick in 1915. Jefferson Middleton.

Silica in 1915. Frank J. Katz.

Spirit Leveling in Louisiana, 1903 to 1915, inclusive; Spirit Leveling in Maine, 1899–1915; Spirit Leveling in West Virginia, 1896 to 1915, inclusive; Triangulation in Arizona and New Mexico, 1913–15. R. B. Marshall.

Water-Supply Papers 383 and 398.

Measuring and Marketing Woodlot Products. Wilbur R. Mattoon and William B. Barrows.

**State Reports.**

Connecticut. Annual Report of Public Utilities Commission for 1915.

Maine. Annual Report of Public Utilities Commission for 1915, Vol. II.

Massachusetts. Annual Report of Harbor and Land Commissioners for 1915.

Massachusetts. Annual Report of Highway Commission for 1915.

Massachusetts. Annual Report of Metropolitan Park Commissioners for 1915.

Massachusetts. Annual Report of Metropolitan Water and Sewerage Board for 1915.

Massachusetts. Annual Report of State Board of Health for 1914.

Massachusetts. Proceedings of Third Annual City and Town Planning Conference of Massachusetts Planning Boards, 1915.

Massachusetts. Report of State Department of Health and Municipal Council of City of Lynn upon Plan for Disposal of Sewage in City of Lynn.

Michigan. Investigation into Causes of Typhoid Fever Epidemic at Monroe, Michigan, 1915.

New Hampshire. Biennial Reports of State Department of Highways for 1909–14.

New Jersey. Annual Report of Department of Conservation and Development for 1915.

New York. Public Service Commission for First District: Map Showing Routes and Stations on Dual System. Gift of H. S. Knowlton.

Ohio. Annual Report of State Board of Health for 1914.

Rhode Island. Annual Report of Public Utilities Commission for 1915.

Wisconsin. Physical Geography of Wisconsin. Lawrence Martin.

**Municipal Reports.**

Albany, N. Y. Annual Report of Bureau of Water for 1915.

Boston, Mass. Boston's Streets, 1916.

Boston, Mass. City Planning Board: Annual Report for 1915; East Boston, a Survey and Comprehensive Plan; Summary of Market Situation in Boston.

Boston, Mass. Reports of Finance Commission for 1914 and 1915.

Brockton, Mass. Annual Report of City Engineer for 1915.

Cambridge, Mass. Annual Report of City Engineer for 1914.

Erie, Pa. Annual Report of Commissioners of Water Works for 1915.

Fall River, Mass. Annual Report of City Engineer for 1915.

Gloucester, Mass. Annual Report of Water Commissioners for 1915.

Haverhill, Mass. Annual Report of City Engineer for 1915.

Haverhill, Mass. Annual Report of Water Commissioners for 1915.

Holyoke, Mass. Water Rates, Rules, etc., 1915.

Marlborough, Mass. Annual Report of Water and Sewage Commission for 1915.

New Orleans, La. Semi-annual Report of Sewerage and Water Board, December, 1915.

Newton, Mass. Annual Report of Street Commissioner for 1915.

Northampton, Mass. Annual Reports of City Officers for 1915.

Revere, Mass. Annual Report of Public Works Department for 1915.

Somerville, Mass. Annual Reports for 1915.

Waltham, Mass. Annual Report of City Engineer for 1915.

Wilmington, Del. Annual Reports of Water Commissioners for 1911–12 to 1914–15.

Woburn, Mass. Annual Report of Department of Public Works for 1915.

Woonsocket, R. I. Annual Report of Water Commissioners for 1915.

## Miscellaneous.

Abolish the Fahrenheit Thermometer. Hon. Albert Johnson.

American Electric Railway Association. Studies in Cost of Urban Transportation Service. F. W. Doolittle. Gift of H. S. Knowlton.

Canada. Department of Mines: Preliminary Report on Mineral Production of Canada for 1915, by John McLeish; Description of Laboratories of Mines Branch of Department of Mines, Ottawa; Investigation of Reported Discovery of Phosphate in Alberta, by Hugh S. de Schmid; Annual Report on Mineral Production of Canada during 1914, by John McLeish; Investigation of Peat Bogs and Peat Industry of Canada, 1913–14, by Aleph Anrep.

Planning of Modern City. Nelson P. Lewis.

Design and Construction of Dams. 6th ed. Edward Wegmann.

Engineer in War. P. S. Bond.

Highway Bridge Floors. Charles M. Spofford. Gift of author.

International Engineering Congress, 1915. Transactions: Waterways and Irrigation; Railway Engineering; Materials of Engineering Construction; Metallurgy; Miscellany.

Metallurgy of Iron and Steel. Bradley Stoughton.

National Board of Fire Underwriters: Shingle Roofs as Conflagration Spreaders; Special Report on Conflagration, March 22 and 23, 1916, Augusta, Ga.; Special Report on Conflagration of March 21, 1916, Paris, Tex.; Reports on following cities: Baltimore, Md.; Binghamton, N. Y.; Cambridge, Mass.; Canton, Ohio; Charleston, W. Va.; Chicago, Ill.; Council

Bluffs, Ia.; Elizabeth, N. J.; Evanston, Ill.; Green Bay, Wis.; Huntington, W. Va.; Joliet, Ill.; Kansas City, Kan.; Kansas City, Mo.; Meridian, Miss.; Milwaukee, Wis.; Montgomery, Ala.; Muskogee, Okla.; Nashville, Tenn.; Oklahoma City, Okla.; Oshkosh, Wis.; Philadelphia, Pa.; Portsmouth, Va.; Racine, Wis.; Roanoke, Va.; Rockford, Ill.; Savannah, Ga.; Sheboygan, Wis.; Sioux City, Ia.; Somerville, Mass.; Tulsa, Okla.; Wheeling, W. Va.

National Lumber Manufacturers Association: Heavy Timber Mill Construction Buildings. C. E. Paul.

Patents and How to Obtain Them. Watson E. Coleman.

Profitable Inventions. Watson E. Coleman.

Direct-acting Steam Pumps. Frank F. Nickel.

Extent to which Sewage can be Purified by Practical Methods of Artificial Treatment Now in Use. Harrison P. Eddy. Gift of author.

United Shoe Machinery Co.; Efficiency through Hygiene; Story of Three Partners: Good Sport, Good Health, Good Work.

Fundamental Principles of Public Utility Valuation. John W. Alvord. Gift of author.

Water-works Handbook. Alfred Douglas Flinn, Robert Spurr Weston and Clinton Lathrop Bogert.

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The Society is indebted to Mr. Harrison P. Eddy for a subscription to the *American Journal of Public Health*, and to Mr. Desmond FitzGerald for a considerable number of books and pamphlets not as yet listed.

A member of the Society wishes to obtain a copy of "One Hundred and Fifteen Experiments on Carrying Capacity of Large Riveted Metal Conduits," by Clemens Herschel, which book is now out of print. He would appreciate information as to where a copy can be purchased.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

**United States Government.** — NAVY DEPARTMENT. — *Navy Yard, Boston.* — The yard railroad system is being reconstructed.

**Commonwealth of Massachusetts.** — METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Alewife Brook Parkway.*—Surfacing and finishing Alewife Brook Parkway, from Massachusetts Ave. to Powder House Boulevard.

*Charles River Reservation.*—Building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown. A. G. Tomasello, contractor.

Building reinforced concrete bridge over the Charles River at Commonwealth Ave., Newton and Weston. T. Stuart & Son Company, contractor.

*Furnace Brook Parkway.*—The construction of parkway extension from Quincy Shore Reservation to Hancock St. John Cashman & Sons Company, contractor.

*Old Colony Parkway.*— Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

*General.*—Road surfaces in all divisions are being repaired.

**Boston Transit Commission.** — The Dorchester Tunnel has been practically completed from its beginning at Tremont St. for about 6 600 linear feet to a point under Dorchester Ave. in South Boston, near Broadway. There is, however, some work being done at the shaft in West First St. in connection with stairways for an emergency exit and a ventilating chamber.

Work is progressing on the Broadway Station, which extends in Dorchester Ave. from Broadway to West Fourth St. The T. A. Gillespie Co. is the contractor.

Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is in progress. Coleman Brothers are the contractors.

Section H and Section H Extension, which are completed, extend from Old Colony Ave. to near Dexter St.

The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to near Ralston St. and embracing the station in Andrew Sq., is being constructed. The T. A. Gillespie Co. is the contractor.

**Boston Elevated Railway Co.** — *Everett Extension.* — Work on the Everett Extension is proceeding at the bridges (Malden Bridge and the new Mystic River Bridge), which are under contract to the Hugh Nawn Contracting Company.

On the Mystic River Railway Bridge, four of the river piers are completed and all of the smaller foundations for the viaduct north of the bridge proper and as far as the old almshouse are completed. Work is under way on the four deep channel piers. Bottoms of these piers are to be thirty feet below low water, and steel sheeting for the cofferdam of the main pier is being driven at the present time.

On the reconstruction of the Malden Bridge, the portion south of new draw and north of the present draw opening is partially completed, floor planking being in place and the waterproofing and paving under way. North of the new draw the retaining wall on the lines of the street as relocated has been commenced.

**New York, New Haven & Hartford R. R. Co.** — It is proposed to four-track the present two-track South Boston Cut, which is the approach to the Boston Freight Terminal. Two additional tracks are to be constructed and eleven overhead bridges rebuilt so as to span four tracks instead of two.

Work not yet started.

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Ten submarines for U. S. Navy.
One submarine for Royal Spanish Navy.
Two oil tankers for Texas Co.
One molasses tanker for Cuba Distilling Co.
One oil tanker for Argentine Republic.
Five cargo vessels for E. F. Luckenbach.
Two oil tankers for Pan-American Petroleum Co.

Vol. III OCTOBER, 1916 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, OCTOBER 18, 1916,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. H. Whittemore Brown will present a paper entitled, "The Groined Arch as a Means of Concrete Floor Construction." It will be illustrated with lantern slides.

S. E. TINKHAM, *Secretary*.

## PAPER IN THIS NUMBER.

"The Groined Arch as a Means of Concrete Floor Construction." H. Whittemore Brown.

### CURRENT DISCUSSIONS.

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "The Commercial Fertilizer Industry." | L. W. Tucker. | Sept. | Nov. 10 |
| "The Sewage Disposal Problem Confronting Philadelphia." | W. L. Stevenson. | Sept. | Nov. 10 |

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "Transforming Latitude and Longitude into Plane Coordinates." | S. H. Thorndike. | Sept. | Nov. 10 |



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

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## MINUTES OF MEETING.

Boston, Mass., September 20, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the Senior Vice-President, Ralph E. Curtis.

There were 94 members and visitors present.

By vote, the record of the June meeting was approved as printed in the September Journal.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Arthur Leon Ford and Nassime Solomon Klink.

Junior — Benjamin Harrison Snow.

The Secretary further announced that the Board of Government had leased Room 709 in Tremont Temple, adjoining those already used for the Society quarters, at a rental of $450 per year, and had arranged for the Hersey Manufacturing Company to move to the new room and for the New England Water Works Association to take the room heretofore used by that company, the Society to receive $300 additional rent on account of the changes made.

Memoirs of deceased members were received and ordered printed in the Journal, as follows: That of Edmund K. Turner, prepared by Past President George F. Swain; that of Samuel Foster Jacques, prepared by William Nelson, F. Herbert Snow and Harrison P. Eddy; and that of Charles Wilson Ross, prepared by William E. McClintock, Edwin H. Rogers and George E. Stuart.

Mr. Eugene E. Pettee then presented a very interesting paper entitled, "The Construction of the Portland Bridge." The paper was illustrated by a large number of lantern slides.

A short discussion followed, and Mr. Pettee answered a number of questions in relation to the construction of the bridge.

Adjourned.

S. E. Tinkham, *Secretary.*

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## ORGANIZATION OF A NATIONAL ENGINEER RESERVE.

The War Department has formulated a plan for the organization of a Reserve Corps of Engineers, and issues an invitation to the engineers of the country to apply for commissions in it. Complete information as to the requirements for commissions in the several grades from second lieutenant to major is now available, together with the method of procedure to be followed to secure such commissions.

Information may be secured by addressing the Engineer Officer, U. S. A., Rivers and Harbors, Barristers Hall, Pemberton Square, Boston, Mass.

The following information has been obtained:

No oral or professional examinations will be required, but recommendations of boards will be required in lieu of such examinations. Candidates will submit evidence of their actual employment in corresponding or higher positions in civil life, and references to persons under whom they have been or are employed. The boards will communicate with such persons and with any others that they deem fit, and upon all the evidence submitted or otherwise obtained will base their recommendations and recommend the appropriate grades for which they deem the successful candidates qualified.

Military experience or training in the regular army, volunteers or national guard, or at training camps or educational institutions, will be noted and reported by the board and considered in making the recommendations.

Reserve officers from the following civilian occupations will be required for the special services of the Corps of Engineers: Bridge engineers, constructing engineers (earth and concrete), constructing engineers (wharves, piers and buildings), electrical engineers (for small plants and power lines), highway engineers, mining engineers (skilled in tunneling and use of explosives), railroad engineers (construction and maintenance), railroad operating officials, sanitary engineers, topographical engineers.

## INTERESTING NOTES ABOUT MEMBERS OF THE SOCIETY.*

For the benefit of friends, I wish to state that the publication of my obituary in a recent issue of an engineering magazine was a serious mistake. I am thankful to say I am well and very much alive.

FRANK LEMUEL CLAPP.

BOSTON, October 4, 1916.

MR. L. K. ROURKE has been retained to make an investigation and report of a railroad in Chile. He sailed from New York on September 9 and was due at Santiago on October 5.

## APPLICATION FOR MEMBERSHIP.

[October 4, 1916.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications re-

* It is proposed to publish personal notes in the JOURNAL, provided the members show their interest by sending them to the editor.

lating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

FRASER, CHARLES EDWARD KINGSTON, Peterboro, N. H. (Age 38, b. England.) Graduate of International Correspondence Schools, 1910. From 1901 to 1907, engaged in landscape engineering; from Aug., 1907, to April, 1908, inspector for Engineer Corps, Pennsylvania Tunnels, New York to Long Island City; from April, 1908, to July, 1916, engaged in landscape engineering and construction; from July, 1916, to date, engineer of construction, All Saints Church, Peterboro, N. H.; has executed plans for various architectural firms of Boston and New York; is at present working on plans of Cram & Ferguson, Boston. Refers to G. P. Connolly, S. J. Connolly, T. F. Gray, B. L. Makepeace, J. C. Olmstead and G. F. Webb.

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## LIST OF MEMBERS.

ADDITIONS.

CHASE, GUY H. .......... Fitchburg, Mass.
KLINK, NASSIME S. .......... 309 Washington St., Quincy, Mass.
NAWN, LEO JOSEPH .......... 188 Seaver St., Roxbury, Mass.
SNOW, BENJAMIN H. .......... 86 Wyllis Ave., Everett, Mass.

CHANGES OF ADDRESS.

BROWN, T. MORRIS .......... 38 N. Burnett St., East Orange, N. J.
CARTER, GALE A. .......... Box 54, East Brownfield, Me.
COBURN, WILLIAM H. .......... Waverley, Mass.
COFFIN, S. P. .......... 8 Roland St., Charlestown, Mass.
CUNTZ, WILLIAM C. .......... 120 Broadway, New York, N. Y.
DEMING, GUY S. .......... 128 East 19th St., New York, N. Y.
GREEN, HOWARD W. .......... Y. M. C. A., Elyria, Ohio
HURD, STEPHEN P. .......... 519 Cutler Bldg., Rochester, N. Y.
MCCORKINDALE, RALPH I. .......... 32 Laurel St., Fairhaven, Mass.
ROBINSON, ASHLEY Q. .......... 81 Richardson St., Newton, Mass.
RUNELS, RALPH E. .......... 783 Main St., Laconia, N. H.
SANDO, WILL J. .......... 1312 Wells Bldg., Milwaukee, Wis.
SOKOLL, JACOB M. .......... 32 State St., Cumberland Mills, Me.
TURNER, CHARLES C. .......... 37 Taylor St., Wollaston, Mass.

DEATH.

SHEDD, FRANK EDSON .......... September 22, 1916

## EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### Men Available.

No. 372. Age 26. Student for three years at Huntington School, Boston, course in mechanical drawing; is now correspondence school student in mechanical engineering. Desires position as mechanical draftsman or tracer. Salary desired, $10 per week.

No. 373. Age 32. Educated at Union College and Albany Law School. Has had twelve years' experience with General Electric Co., including computation of costs, prices, discounts, quotations, factory statistics and production; requisition work in order department at New York office; general office work as assistant to manager of sales department and supervision of special manufacturing. Desires position as office manager, with chance for advancement. Salary desired, $1 800 per year.

No. 374. Age 32. Educated in public schools, normal school and at Boston University. Experience consists of work in civil engineering departments of M. K. T. R. R., G. C. & S. F. R. R., and B. & M. R. R.; dam construction, Pittsfield, Mass.; and work with Crosby Steam Gauge Co., Charlestown, Mass. Desires work on hydraulic problems. Salary desired, $5 000 per year.

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## LIBRARY NOTES.

### Book Review.

Examples in Magnetism, by Prof. F. E. Austin, Hanover, N. H. 2d ed. 1916. Leather, 5 by 8 in., 90 pages. $1.10.

*Reviewed by Howard S. Knowlton.*

The author of this work has produced a clear-cut and interesting handbook of pocket size which is bound to be useful to all students of magnetic problems. The book is printed in green ink on rough paper, so that its use under artificial light can be enjoyed without the strain upon eyesight frequently induced by glazed paper. It includes much valuable data in regard to symbols, metric units and equivalents, and trigonometric functions, followed by a large number of problems and examples of the application of various magnetic theories. In each case an example is given, with the algebraic or symbolic expression denoting the physical law applying, with the given data systematically tabulated. This is followed by a solution, the process of which is explained at every step. Every solution is then followed by a problem to which the answer but not the detailed working out is given, and the problem is followed by another dealing with some phase of the same subject, to which no answer is given. A vast amount of information upon this important though somewhat specialized subject is included in the ninety pages of this little work, one of the most interesting to the civil engineer being a table of the three variable magnetic elements for the principal states and territorial possessions of the country.

## Recent Additions to the Library.

**U. S. Government Reports.**

Anticlinal Fold near Billings, Noble County, Oklahoma. A. E. Fath.

Antimony Deposits of Alaska. Alfred H. Brooks.

Reconnaissance of Archean Complex of Granite Gorge, Grand Canyon, Arizona. L. F. Noble and J. Fred. Hunter.

Asphalt, Related Bitumens, and Bituminous Rock in 1915. John D. Northrop.

Brick Roads. Vernon M. Peirce and Charles H. Moorefield.

Chisana-White River District, Alaska. Stephen R. Capps.

Gypsum in 1915. Ralph W. Stone.

Lignite Field of Northwestern South Dakota. Dean E. Winchester and others.

Lode Mining in Quartzburg and Grimes Pass Porphyry Belt, Boise Basin, Idaho. E. L. Jones.

Manganese and Manganiferous Ores in 1915. D. F. Hewett.

Molybdenite and Nickel Ore in San Diego County, California. F. C. Calkins.

Possibilities of Oil and Gas in North-Central Montana. Eugene Stebinger.

Some Paleozoic Sections in Arizona and Their Correlation. Frederick Leslie Ransome.

Mechanics of Panama Slides. George F. Becker.

Potash Salts, 1915.

Pottery in 1915. Jefferson Middleton.

Public Road Mileage and Revenues in Middle Atlantic States, 1914.

Secondary Metals in 1915. J. P. Dunlop.

Silver, Copper, Lead, and Zinc in Central States in 1915. J. P. Dunlop and B. S. Butler.

Spirit Leveling in Arkansas, 1896 to 1915, inclusive. R. B. Marshall.

Talc and Soapstone in 1915. J. S. Diller.

Triangulation in California, 1913–1915. R. B. Marshall.

Structure of Vicksburg-Jackson Area, Mississippi, with Special Reference to Oil and Gas. Oliver B. Hopkins.

Water-Supply Papers 360, 384, 387 and 399.

**Municipal Reports.**

Baltimore, Md. Annual Report of Sewerage Commission for 1913.

Baltimore, Md. Annual Report of Water Board for 1914.

Newton, Mass. Annual Report of City Engineer for 1915.

Reading, Pa. Annual Report of Bureau of Water for 1914.

St. Louis, Mo. Annual Report of Water Comm'ssioner for 1915.

St. Paul, Minn. Annual Report of Water Commissioners for 1915.

Salt Lake City, Utah. Annual Reports of City Officers for 1915.

Salt Lake City, Utah. Corporation Appropriation Budget for 1916.

**Miscellaneous.**

What can Best be Done to Advance the Interests of the Engineering Profession in the United States? J. A. L. Waddell. Gift of author.

Federal Valuation of Common Carriers. James Poyntz Nelson.

Institution of Civil Engineers (London). Minutes of Proceedings, Vol. CCI.

Lehrbuch der Ingenieur- und Maschinen-Mechanik. 4 vols. Julius Weisbach. Gift of E. C. Sherman.

Mechanical Engineers' Handbook. Lionel S. Marks, Ed.

Washington Irrigation Institute: Proceedings of Third Annual Meeting, 1916.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

**United States Government.** — NAVY DEPARTMENT. — *Work Contemplated.* — Magazine buildings of concrete and tile construction, Naval Magazine, Hingham, Mass.; workmen's locker and lavatory rooms, Navy Yard, Boston; sea wall of granite, Naval Hospital, Chelsea, Mass.; 5 000 cu. ft. capacity air compressor, Navy Yard, Boston, Mass.

**Commonwealth of Massachusetts.**—METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work is in progress on the extension of Deer Island sewer outfall, the removal of old Malden River sewer siphon, survey work for Reading extension of Metropolitan sewer, and work on Sections 98, 103, 104, Wellesley Extension.

Bids are advertised for Section 102, Wellesley Extension, and installation of 50 000 000-gal. pumping unit for Ward Street Pumping Station.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Alewife Brook Parkway.* — Surfacing and finishing Alewife Brook Parkway from Massachusetts Ave. to Powder House Boulevard.

*Charles River Reservation.* — Building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown, A. G. Tomasello, contractor; and reinforced concrete bridge over the Charles River at Commonwealth Ave., Newton and Weston, T. Stuart & Son Company, contractor.

*Furnace Brook Parkway.* — Surfacing roadway from Quincy Shore Reservation to Hancock St.

New work includes the

*Mystic Valley Parkway.* — Contract has been awarded to James H. Fannon for grading extension of Mystic Valley Parkway from Mystic St. to Medford St., Arlington.

*Old Colony Parkway.* — Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

**Boston Transit Commission.** — The Dorchester Tunnel has been practically completed from its beginning at Tremont St. to a point under Dorchester Ave. in South Boston, near Broadway. Work is progressing on the Broadway Station, which extends in Dorchester Ave. from Broadway to West Fourth St. The T. A. Gillespie Co. is the contractor. Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is in progress. Coleman Brothers are the contractors. Section H and Section H Extension, which are completed, extend from Old Colony Ave. to near Dexter St. The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to near Ralston St., and embracing the station in Andrew Square, is being constructed. The T. A. Gillespie Co. is the contractor.

**City of Boston.** — Public Works Department, Highway Division, Paving Service. — Work is in progress on the following streets:

| | | |
|---|---|---|
| Condor St., | Glendon St. to Eagle St. | Sea wall. |
| Washington St., | from Morton St. to Asticou Rd. | Granite block. |
| Bardwell St., | from South St. to Ballard St. | Asphalt. |
| Hillcrest St., | from Elgin St. to Temple St. | Asphalt. |
| Lorette St., | from Centre St. to Hillcrest St. | Asphalt. |
| Temple St., | from Ivory St. to Spring St. | Asphalt. |
| Columbia Rd., | from Edward Everett Sq. to Dudley St. | Granite block. |
| Everton St., | from Geneva Ave. to Olney St. | Asphalt. |
| Normandy St., | from Intervale St. to Devon St. | Asphalt. |
| Alexander St. | from Bird St. 527 ft. northerly. | Granite block. |
| Eric Ave., | from Savin Hill Ave., northerly. | Asphalt. |
| Crown Path, | from Claybourne St. to Washington St. | Artificial steps. |
| Ripley Rd., | from Harvard St. to Vassar St. | Asphalt. |
| Harwood St., | from Willowwood St. to Lucerne St. | Asphalt. |
| Corbet St., | from Norfolk St. to Morton St. | Artificial walks. |
| Dorchester Ave. | from Savin Hill Ave. to Freeport St. | Granite block. |
| Randall St., | from Harrison Ave. to Albany St. | Asphalt. |
| West Canton St., | from Tremont St. to Appleton St. | Asphalt. |
| Chandler St., | from Berkeley St. to Columbus Ave. | Asphalt. |
| Batterymarch St., | from Franklin St. to Broad St. | Granite block. |
| Norway St., | in front of Christian Science Church. | Artificial walks. |

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Eleven submarine boats.
Five cargo vessels for the Luckenbach Co., Inc.
One cargo vessel for the Cuba Distilling Co.
Two oil tankers for the Texas Co.
Two tank steamers for the Petroleum Transport Co.
Two stock cargo vessels.

Vol. III | NOVEMBER, 1916 | No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, NOVEMBER 15, 1916,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Nathan C. Grover will present a paper entitled, "Effect of Channel on Stream Flow."

S. E. TINKHAM, *Secretary*.

## PAPERS IN THIS NUMBER.

"Effect of Channel on Stream Flow." Nathan C. Grover.
Memoirs of deceased members.

### CURRENT DISCUSSION.

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "Groined Arch Floor Construction." | H. W. Brown. | Oct. | Dec. 10. |



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

## MINUTES OF MEETING.

Boston, Mass., October 18, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8.15 by the President, Richard A. Hale.

There were present 60 members and visitors.

By vote, the record of the last meeting was approved as printed in the October Journal.

The President reported for the Board of Government the election of the following to membership in the Society in the grade of member:

Frank Charles Bell and William Newell Wade.

The Secretary presented the memoir of Emory A. Ellsworth, prepared by a committee consisting of James L. Tighe and Albert H. Lavalle, and by vote it was accepted and ordered to be printed in the Journal.

The Secretary also announced the death of Frank E. Shedd, a member of the Society, which occurred on September 22, 1916. By vote, the President was requested to appoint a committee to prepare a memoir. The President has named, as that committee, Mr. Charles T. Main.

The Secretary read a communication from the Massachusetts Civil Service Commission, asking the coöperation of this Society in a revision of its rules and in its consideration of a new classification of civil engineers, as applied to that service.

By vote, the President was requested to appoint a committee, as suggested in the communication. The President has selected the following as the membership of that committee: Frederick H. Fay, Charles R. Gow, Rufus M. Whittet, John E. Carty and Edwin H. Rogers.

Mr. H. Whittemore Brown then presented the paper of the evening, entitled, "The Groined Arch as a Means of Concrete Floor Construction," which is printed in the October number of the Journal. The reading of the paper was illustrated by lantern slides.

The paper was discussed by Past President Gow and Messrs. F. L. Fuller, J. R. Nichols, H. W. Hayward and others.

Adjourned.

S. E. Tinkham, *Secretary.*

## APPLICATIONS FOR MEMBERSHIP.

[November 4, 1916.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Breen, Anthony Andrew, Somerville, Mass. (Age 21, b. Somerville, Mass.) Received technical education in evening courses at Wentworth Institute and Franklin Union, where he completed three years' course in structures, March, 1915. From June, 1911, to June, 1914, junior draftsman with Boston Elevated Railway Co., Architectural Division; from July to Oct., 1914, with Stone & Webster, detailing reinforced concrete; from Feb. to Dec., 1915, draftsman with Hub Wire Cloth & Wire Work Company; from Jan., 1916, to date, estimator with same concern. Refers to E. H. Rockwell, R. C. Smith, F. S. Wells and J. M. Wiseman.

Bresth, Alexander, Boston, Mass. (Age 22, b. East Boston, Mass.) Graduate of Mass. Inst. of Technology, 1916, sanitary engineering course. Is now assistant sanitary engineer with Massachusetts State Department of Health. Refers to H. E. Holmes, Dwight Porter, C. M. Spofford, G. C. Whipple and Edward Wright, Jr.

Bryant, William Allen, Brookline, Mass. (Age 26, b. Brookline, Mass.) Completed five-year course in civil engineering at Mass. Inst. of Technology, degree of S.B. During summers worked as rodman and transitman with H. F. Bryant, Brookline; in 1914, resident engineer with L. D. Thorpe, Boston, on construction of concrete dam; from spring of 1915 to date, in charge of office of H. F. Bryant. Elected a Junior December 20, 1911, and now desires to be transferred to grade of member. Refers to

C. F. Allen, H. F. Bryant, A. E. Burton, C. M. Spofford and S. E. Tinkham.

CROSIER, CHARLES LEAVETT, Boston, Mass. (Age 21, b. Hadley, Mass.) Graduate of Mass. Inst. of Technology, 1916, sanitary engineering course. Is now assistant in civil engineering at Mass. Inst. of Technology. Refers to H. K. Barrows, G. L. Hosmer, J. W. Howard, Dwight Porter, C. M. Spofford and G. C. Whipple.

KNOWLTON, ARTHUR WILLIAM, Rockport, Mass. (Age 26, b. Boston, Mass.) Graduate of Worcester Polytechnic Inst., 1914, degree of B.S. in civil engineering. From July, 1914, to Aug., 1915, assistant bridge inspector, fourth division, B. & M. R. R.; from Aug., 1915, to date, bridge inspector, first division, B. & M. R. R. Elected a Junior January 27, 1915, and now desires to be transferred to grade of member. Refers to C. M. Allen, B. W. Guppy, E. A. Norwood and H. P. Wires.

NOLAN, CONRAD, Somerville, Mass. (Age 25, b. Jacksonville, Fla.) Graduate of Tufts College, 1913, structural engineering course. During summer of 1910, timekeeper with Charles R. Gow Co., Boston, on concrete sewer in West Roxbury; during summers of 1911 and 1912, and from June, 1913, to date, with G. M. Bryne Co., general contractors, on concrete bridge construction and on sewer construction, including four sections of Metropolitan sewer. Elected a Junior January 25, 1911, and now desires to be transferred to grade of member. Refers to C. R. Gow, E. S. Larned, C. A. Leary, E. H. Rockwell, F. B. Sanborn and F. D. Smith.

STROUT, HENRY ELMER, Jr., Roxbury, Mass. (Age 22, b. Roxbury, Mass.) Student at Mass. Inst. of Technology, class of 1917, engineering administration course. During summer of 1916 with Aberthaw Construction Company. Refers to C. B. Breed, G. L. Hosmer, H. B. Luther and C. M. Spofford.

VAN DER PYL, EDWARD, Worcester, Mass. (Age 28, b. Worcester, Mass.) Student with American School of Correspondence from 1909 to date, courses in advanced mathematics, bridge engineering and steel construction. From Dec., 1906, to July, 1907, apprentice machinist with F. E. Reed Machine Tool Co.; from July to Oct., 1907, draftsman with Worcester Envelope Co.; from Oct., 1907, to Jan., 1909, designer for Reed & Prince Mfg. Co.; from Jan., 1909, to date, with engineering department of Norton Company, as draftsman and designer and, since Aug., 1916, inspector of construction. Refers to A. W. French, H. L. Robinson and J. A. Tosi.

## LIST OF MEMBERS.

ADDITIONS.

BELL, FRANK C. .............................. 23 Spring St., Malden, Mass.
FORD, ARTHUR L. ......................... 28 Evelyn Place, Malden, Mass

CHANGES OF ADDRESS.

Ackerman, Alexander S. . . . . . . . . . . . . . . . 64 Seminary Ave., Rahway, N. J.
Babbitt, John H., Mass. Inst. of Technology Dormitories, Cambridge, Mass.
Babcock, Paul A. . . . . . . . . . . . . . . . . . . . . . 557 Adams St., East Milton, Mass.
Bowers, George W. . . . . . . . . . . . . . . . . . . . 4008 Prospect Ave., Cleveland, Ohio
Chevalier, Charles R. . . . . . . . . . . . . . . . . . 64 Dartmouth St., Portland, Me.
Foster, Howard L. . . . . . . . . . . . . . . . . . . . 1137 Mass. Ave., Cambridge, Mass.
French, Herman W. . . . . . . . . . . . . . . . 701–2 Tremont Building, Boston, Mass.
Hammatt, Edward A. W. . . . . . . . . . . . . . . . . . . . . . . . . . . South Orleans, Mass.
Hodges, Arthur W. . . . . . . . . . . . . . . . . 46 West Rosseter St., Brockton, Mass.
Joy, C. Frederick, Jr. . . . . . . . . . . . . . . . . . 187 Reedsdale Road, Milton, Mass.
Morrison, Harry J. . . . . . . . . . . . . . . . . . . . . . . . . . . Box 197, Beckley, W. Va.
Shorrock, John W. . . . . . . . . . . . . . . . . . . . . . . . . . . . . Box 17, Milton, N. H.
Skillin, Fred B. . . . . . . . . . . . . . . . . . . . 4415 8th St. N. W., Washington, D. C.
Smith, Edward R. . . . . . . . . . . . . . . . . . . . . . . . 26 Hancock St., Malden, Mass.
Taylor, Philip W. . . . . . . . . . . . . . . . . . . . . . . . . 115 Beech St., Waverly, Mass.
Tisdale, Ellis S. . . . . . . . . . . State Department of Health, Charleston, W. Va.
Wells, Charles E. . . . . . . . . . . . . . . . . . . . . 7 Prospect St., White Plains, N. Y.
Whiting, Mason T. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Holter, Mont.
Whitney, Ralph E., 191 Powder House Boulevard, West Somerville, Mass.

DEATHS.

Bolton, Edward D. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . March 10, 1916
Cuntz, William C. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . November 2, 1916
Ellis, John W. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . October 30, 1916

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## EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### Men Available.

No. 375. Age 22. Student for two years at Mass. Agricultural College. Has had no practical experience. Desires position as rodman.

No. 376. Age 20. Graduate of Lowell Inst. School for Industrial Foreman, 1916, buildings course. Has had four years' experience as rodman, transitman, draftsman, etc., with town engineering department. Desires position as transitman or draftsman. Salary desired, $16 to $18 per week.

No. 377. Age 24. Student for one year at Mechanic Arts Evening School, one year at Y. M. C. A., and one year at Franklin Union. Has had about five years' experience, chiefly as rodman and transitman, on laying out of sewers, preliminary survey for water power development, etc. Desires position as chief of party or inspector on sewer work. Salary desired, $100 per month.

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## LIBRARY NOTES.

### Recent Additions to the Library.

**U. S. Government Reports.**

Accidents at Metallurgical Works in United States during Calendar Years 1913 and 1914. Albert H. Fay.

Analysis of Permissible Explosives. C. G. Storm.

Bauxite and Aluminum in 1915. W. C. Phalen.

Bibliography of North American Geology for 1915 with Subject Index. John M. Nickles.

Black Damp in Mines. G. A. Burrell and others.

Brass-Furnace Practice in United States. H. W. Gillett.

Casting of Clay Wares. Taine G. McDougal.

Catahoula Sandstone and Its Flora. George Charlton Matson and Edward Wilber Berry.

Cement in 1915. Ernest F. Burchard.

Condensation of Gasoline from Natural Gas. George A. Burrell and others.

Compressibility of Natural Gas at High Pressures. G. A. Burrell and I. W. Robertson.

Construction and Operation of Single-Tube Cracking Furnace for Making Gasoline. C. P. Bowie.

Determination of Nitrogen in Coal. Arno C. Fieldner and Carl A. Taylor.

Economic Methods of Utilizing Western Lignites. E. J. Babcock.

Effects of Atmospheres Deficient in Oxygen on Small Animals and on Men. George A. Burrell and G. G. Oberfell.

Effects of Temperature and Pressure on Explosibility of Methane-Air Mixtures. G. A. Burrell and I. W. Robertson.

Electric Furnace in Metallurgical Work. Dorsey A. Lyon and others.

Electric Furnaces for Making Iron and Steel. Dorsey A. Lyon and Robert M. Keeney.

Explosibility of Acetylene. George A. Burrell and G. G. Oberfell.

Explosibility of Gases from Mine Fires. George A. Burrell and George G. Oberfell.

Production of Explosives in United States during Calendar Year 1915. Albert H. Fay.

Extraction and Recovery of Radium, Uranium and Vanadium from Carnotite. Charles L. Parsons and others.

Feldspars of New England and North Appalachian States. A. S. Watts.

Gasoline Mine Locomotives in Relation to Safety and Health. O. P. Hood and R. H. Kudlich.

Hazards in Handling Gasoline. George A. Burrell.

Health Conservation at Steel Mills. J. A. Watkins.

Inflammability of Illinois Coal Dusts. J. K. Clement and L. A. Scholl, Jr.

Lime in 1915. G. F. Loughlin.

Limits of Inflammability of Mixtures of Methane and Air. G. A. Burrell and G. G. Oberfell.

Manufacture and Uses of Alloy Steels. Henry D. Hibbard.

Metal-Mine Accidents in United States during Calendar Year 1914. Albert H. Fay.

Preservative Treatment of Farm Timbers. George M. Hunt.

Some Properties of Water in Coal. Horace C. Porter and O. C. Ralston.

Quantity of Gasoline Necessary to Produce Explosive Conditions in Sewers. G. A. Burrell and H. T. Boyd.

Quarry Accidents in United States during Calendar Year 1914. Albert H. Fay.

Sand and Gravel in 1915. R. W. Stone.

Salt. Bromine, and Calcium Chloride in 1915. W. C. Phalen.

Sand Test for Determining Strength of Detonators. C. G. Storm and W. C. Cope.

Shot Firing in Coal Mines by Electricity Controlled from Outside. H. H. Clark and others.

Water-Supply Paper 362-B.

**State Reports.**

New York. Annual Report of State Department of Health for 1914.

**Municipal Reports.**

Bangor, Me. Annual Report of Water Board for 1915.

New York, N. Y. Annual Report of Board of Water Supply for 1915.

Newton, Mass. Annual Report of Water Commissioner for 1915.

Providence, R. I. Annual Report of City Engineer for 1915.

**Miscellaneous.**

American Institute of Mining Engineers: Transactions for 1916, Vols. LII and LIII.

Brooklyn Engineers' Club: Proceedings for 1915.

Construction of Roads and Pavements. T. R. Agg.

Hydrated Lime Bureau: Dependable Concrete.

Portland Cement Association: Concrete Feeding Floors, Barnyard Pavements and Concrete Walks; Concrete Fence Posts; Concrete Foundations; Concrete in the Country; Proportioning Concrete Mixtures and Mixing and Placing Concrete; Small Concrete Garages.

Two Hundred Power Plant Pointers.

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The magazines, reports, etc., in the following list are duplicate copies for which the Society has no room in its library. They have been placed on the ends of the tables in the reading room, and members desiring any of them for their own files are at liberty to help themselves. After a reasonable length of time, those remaining will be otherwise disposed of. Similar lists will be published in the JOURNAL from time to time:

*American Architect:* June 14, 1911.

American Society of Civil Engineers: Transactions and Proceedings, August–November, 1895; Transactions, July and December, 1896; December, 1909; March, June, October and December, 1910; March, June, September and December, 1911; December, 1912; December, 1913; December, 1914; Vols. LXXVIII and LXXIX, 1915; Proceedings, January and March, 1897; September, 1909; January–September, November, December, 1910; January, March–May, September, November, December, 1911; January–November, 1912; January, April–December, 1913; Index to Transactions, Vols. I–LXXIV, 1867–1911. Electrification of Suburban Zone of New York Central and Hudson River R. R. in Vicinity of New York City, by William J. Wilgus, 1908. Some Tendencies and Problems of the Present Day and the Relation of the Engineer Thereto, by George Fillmore Swain, 1913. Maximum Rates of Rainfall, by Desmond FitzGerald, 1889. Inland Sewage Disposal with Special Reference to East Orange, N. J., Works, by Carrol Ph. Bassett, 1891.

American Society of Mechanical Engineers: Journal, February and October, 1914.

Association of Engineering Societies: Journal, Vols. 2, 1882–83; 3, 1883–84; 22, 1899; cloth binding.

Association of American Portland Cement Manufacturers: Concrete in the Country; Concrete Silos; Concreting in Winter; Portland Cement Stucco.

Book of Truth and Facts. Fritz von Frantzius.

*Canadian Engineer:* March 26, 1914.

Connecticut Society of Civil Engineers: Proceedings, 1886–88; 1890–97; 1907.

*Electric Railway Journal:* July 4 and 11, 1914.

*Electrical World:* July 21, 1910; March 15, 1913.

*Engineering* (Lond.): January 1, 1915.

*Engineering and Contracting:* March 19, 1913.

*Engineering Magazine:* April–June, 1912; February and May, 1913; June–December, 1915; January–October, 1916.

*Engineering News:* March 16–June 29, 1893; May 31, 1894; April 21, 1898; July 24, 1913; title page and index, Vol. 69, January–June, 1913.

*Engineering Record:* April 3–10, 1915.

Engineers' Society of Western Pennsylvania: Proceedings, January, 1911; December, 1912.

History of Introduction of Pure Water into City of Boston, compiled by Member of Water Board, 1868.

Institution of Civil Engineers (Lond.): Minutes of Proceedings, Vols. 151–168, Part 1, 1902–03, to Part 2, 1906–07; Vols. 170–184, Part 4, 1906–07, to Part 2, 1910–11; Vols. 186–198, Part 4, 1910–11, to Part 4, 1913–14; Vols. 200–201, Part 2, 1914–15, to Part 1, 1915–16.

Iowa State College Engineering Experiment Station: Bulletins 30, Determination of Internal Temperature Range in Concrete Arch Bridges, by C. S. Nichols and C. B. McCullough; 31, Theory of Loads on Pipes in Ditches and Tests of Cement and Clay Drain Tile and Sewer Pipe, by A. Marston and A. O. Anderson.

Mass. Inst. of Technology: Contributions from Sanitary Research Laboratory and Sewage Experiment Station, Vols. 3–6, 8.

*Municipal Engineering:* May–June, 1915.

*Municipal Journal:* July 1–22, August 26, September 2, 1915.

*National Geographic Magazine:* October–December, 1913; January–December, 1914; January–April, 1915.

New England Water Works Association: Transactions for 1883; Journal, September, 1886; September, 1892; June, 1896; December, 1902; March and June, 1903; December, 1912; Report of Committee Appointed to Collect Data Relating to Awards for Water and Water-Power Diversion, December, 1909.

*Railway Age Gazette:* March 20, April 24, May 1, 1914; January 8–May 28, 1915.

*School of Mines Quarterly:* November, 1913.

Tables of Astronomical and Trigonometrical Survey of Massachusetts (Borden's Survey of Massachusetts), 1846.

University of Wisconsin Bulletin: Vol. 4, Nos. 2–6; Vol. 5, complete, with title page and table of contents; Vol. 6, complete, with title page and table of contents; Vol. 7, No. 1.

Water-Supply Papers of U. S. Geological Survey: Nos. 1, 65, 200, 201, 234, 373.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

**United States Government.** — NAVY DEPARTMENT. — *Work in Progress.* — Extension of shipbuilding ways, Navy Yard, Boston, construction of magazine and shell house at Hingham, and rubble sea wall, Naval Hospital, Chelsea.

**Commonwealth of Massachusetts.** — METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Alewife Brook Parkway.*—Surfacing and finishing Alewife Brook Parkway, from Massachusetts Ave. to Powder House Boulevard.

*Charles River Reservation.*—Building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown, A. G. Tomasello, contractor; and reinforced concrete bridge over the Charles River at Commonwealth Ave., Newton and Weston. T. Stuart & Son Company, contractor.

*Mystic Valley Parkway.*—Grading extension of Mystic Valley Parkway from Mystic St. to Medford St., Arlington. James H. Farnum, contractor.

*Nantasket Beach Reservation.*—Building concrete retaining and bulkhead walls southeasterly from roller-coaster. Hugh Nawn Contracting Company, contractor.

*Old Colony Parkway.*—Plans are being prepared for bridge over Neponset River, Boston and Quincy, to replace old wooden bridge.

**Boston Transit Commission.** — *Dorchester Tunnel.* — The status of this work remains as described in the JOURNAL for October.

**City of Boston.** — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

| | | |
|---|---|---|
| Washington St., | Morton St. to Asticou Rd. | Granite block. |
| Ripley Rd., | Harvard St. to Vassar St. | Asphalt. |
| Upland Ave., | Park St. to Melville Ave. | Asphalt. |
| Augustus Ave., | Metropolitan Ave. to Ethel St. | Bituminous macadam. |
| Albany St., | Dover St. to Northampton St. | Granite block. |
| Everton St., | Geneva Ave. to Olney St. | Asphalt. |
| Orchardfield St., | Dorchester Ave. to Freeport St. | Asphalt. |
| Cedric St., | Magazine St. to Langdon St. | Asphalt. |
| Dunster Rd., | Centre St. to Pond St. | Asphalt. |
| Columbia Rd., | Edward Everett Sq. to Dudley St. | Granite block. |
| Dorchester Ave., | Savin Hill Ave. to Freeport St. | Granite block. |
| Batterymarch St., | Franklin St. to Broad St. | Granite block. |
| Hubert St., | Westminster St. to Shawmut Ave. | Asphalt. |
| Hillcrest St., | Elgin St. to Temple St. | Asphalt. |
| Lorette St. | Centre St. to Hillcrest St. | Asphalt. |
| Temple St., | Ivory St. to Spring St. | Asphalt. |
| Bardwell St., | South St. to Ballard St. | Asphalt. |
| Crown Path, | Washington St. to Claybourne St. | Artificial steps. |
| Homestead St., | Humboldt Ave. to Elm Hill Ave. | Asphalt. |
| Alexander St., | Bird St. to 527 ft. northerly. | Granite block. |
| Morton St., | Norfolk St. to N. Y., N. H. & H. R. R. | Artificial walks. |
| School St., | Tremont St. to Washington St. | Granite block. |
| Eric Ave., | Savin Hill Ave. northerly. | Asphalt. |
| Appleton St., | Berkeley St. to Columbus Ave. | Asphalt. |
| Chandler St., | Berkeley St. to Columbus Ave. | Asphalt. |

**Boston Elevated Railway Company.** — BUREAU OF ELEVATED AND SUBWAY CONSTRUCTION. — *Everett Extension.* — *Mystic River Bridge.* On this work the large piers at the draw opening are now being constructed. A steel sheet pile cofferdam 122 ft. by 19 ft. has been completed and the work of laying the concrete seal in the bottom of this cofferdam is under way. The top of this concrete mat is to be at approximately grade 76, to which elevation the cofferdam is to be unwatered, and the balance of the work to high water done in the dry. For the adjacent piers, concrete caissons or boats are to be sunk on top of the piles cut to the proper elevation. All of the concrete above the bottom where the caissons are used is done in the dry. The largest of the three caissons which form the last mentioned piers has been cast, and is now on the ways where the sides are to be attached. This caisson or concrete boat is 124 ft. long, 16½ ft. wide and 4 ft. deep, and the first set of wooden sides which are to be attached are 17 ft. in height. This caisson will probably be launched at an early date next month.

*Malden Bridge.* On the reconstruction of Malden Bridge, which work is being done simultaneously with the railway company's bridge, the heavy sea wall along the westerly line of Alford St. as relocated is now nearing completion and the fill for widening the new street will probably be begun within a short time.

*Egleston Square.* — Foundations for the steel shelter and the supports for the escalator are completed. Steel for the entire shelter is being erected and the contract for the balance of the carpenter and concrete work has been let to Ira G. Hersey & Sons Co. An escalator having a lift of about 30 ft. is to be installed by the Otis Elevator Co.

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

New pattern and joiner shop, and new hospital and employment building nearly completed.

Vol. III DECEMBER, 1916 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

# PROCEEDINGS

## NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, DECEMBER 20, 1916,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Arthur E. Morgan, president of the Morgan Engineering Companies, of Dayton, Ohio, will present an illustrated paper on "Flood Control in the Miami Valley."

S. E. TINKHAM, *Secretary*.

## PAPER IN THIS NUMBER.

"The Portland Bridge." E. E. Pettee.

CURRENT DISCUSSION.

| Paper. | Author. | Published. | Discussion Closes. |
|---|---|---|---|
| "Effect of Channel on Stream Flow." | N. C. Grover. | Nov. | Jan. 10 |



Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

## MINUTES OF MEETINGS.

Boston, Mass., November 17, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, and was called to order at 8.30 o'clock by the President, Richard A. Hale.

There were 65 members and visitors present.

The record of the last meeting was approved as printed in the November Journal.

The President announced the deaths of the following members of the Society:

Edward D. Bolton, died March 10, 1916; William C. Cuntz, died November 2, 1916; and John W. Ellis, a past President of the Society, who died October 30, 1916.

By vote, the President was requested to appoint committees to prepare memoirs of our late associates named above. The President has selected the following committees to prepare the memoirs:

That for memoir of Mr. Bolton, Messrs. Frederic M. Hersey and Daniel W. Pratt.

That for memoir of Mr. Cuntz, Messrs. Charles S. Clark, Benjamin W. Guppy and Gilbert S. Vickery.

That for memoir of Past President Ellis, Mr. John R. Freeman.

Mr. Nathan C. Grover then read the paper of the evening, entitled, " Effect of Channel on Stream Flow." The paper was illustrated with lantern slides. In the discussion which followed, the following participated: Dwight Porter, Dana M. Wood, Frank B. Sanborn, C. H. Pierce and President Hale.

Adjourned.

S. E. Tinkham, *Secretary.*

Boston, Mass., November 1, 1916. — A meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at 7.45 o'clock, in the Society library, Tremont Temple. In the absence of the chairman, Mr. Edward Wright, Jr., Vice-Chairman, presided.

The subject for discussion was " Catch-Basin Construction and Maintenance," and discussion was opened by Mr. George A. Carpenter, city engineer, Pawtucket, R. I., who described the improvements in catch-basin cleaning methods, which have been adopted at Pawtucket, and especially a description of the motor truck, which has been developed by him, for cleaning catch basins in an efficient and economical manner.

The subject was also discussed by Messrs. Lewis M. Hastings, Edgar S. Dorr, George H. Nye, David A. Ambrose, Philip W. Taylor, Gordon H. Fernald and Henry A. Varney. A number of letters containing information and discussions concerning catch basins were received, but were not presented on account of the lack of time and also because the intention is to collect all of the available material for discussion in the JOURNAL.

In connection with the above discussion, lantern slides, drawings and photographs were used to illustrate catch-basin construction and methods of cleaning. A number of opaque objects, such as drawings and photographs, were projected on the screen by means of the lantern, and the results were fairly satisfactory for use in a small room. In order that the whole object shall be clearly illustrated and brought into focus, such drawings or photographs should not be over six inches square. Drawings should be made on white drawing paper or bristol board, and the lines should be bold and show considerable contrast. Colors can be used to bring out sections or other details more prominently.

The meeting adjourned about ten o'clock. There were 60 present.

FRANK A. MARSTON, *Clerk.*

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## RULES RELATING TO REPRINTS OF PAPERS AND DISCUSSIONS.

1. Authors of papers published in the Society's JOURNAL will receive, free of charge, 50 reprint copies of their papers as originally printed in the JOURNAL, in pamphlet form, with covers. Additional reprints, if ordered before publication of the JOURNAL, may be had at the actual cost of paper, press-work and binding.

2. Members of the Society and other persons taking part in discussions shall be entitled to receive, without charge, 3 copies of the JOURNAL in which the discussion is printed, on application to the Secretary.

3. Members can be supplied with reprints of a discussion, at cost, if order is placed before the publication of the JOURNAL containing it.

4. Persons who present written discussion may, at the discretion of the Committee on Publication, be entitled, without charge, to receive not exceeding 25 reprints of the entire discussion published in a single issue of the JOURNAL.

At a meeting of the Board of Government held November 15, 1916, the above rules were adopted.

S. E. TINKHAM, *Secretary.*

## NEW PUBLICATION.

WATER-SUPPLY PAPER 415. "Surface Waters of Massachusetts." By C. H. Pierce and H. J. Dean, 1916. 430 pages, 12 plates, 6 text figures.

This volume contains the results of stream-flow investigations in Massachusetts, and a compilation of the available records. The data are arranged on the basis of the "climatic" year ending September 30, that being the division of the year now generally used by the Geological Survey throughout its work of water resources investigations. The report contains an introduction by Nathan C. Grover, briefly sketching the uses and development of the water resources of Massachusetts, which have at all times played an important part in the industrial and commercial development of the Commonwealth. An article on "Topography," by Arthur Keith, outlines the geologic formations of Massachusetts with especial reference to the various drainage basins, and gives a bird's-eye view of the surface conditions with a non-technical discussion of the different geologic episodes which have contributed to the formation of the river systems. The tables of discharge, showing the flow of the rivers as measured at the gaging stations, are followed by a gazetteer of streams which lists and describes all the streams, lakes and ponds shown on the topographic maps of Massachusetts. A contour map (in pocket) at a scale of 1 : 250,000 (about four miles to the inch) printed in colors shows the principal drainage basins and location of gaging stations. Long-term records of the flow of the Merrimack River at Lowell as compiled by A. T. Safford, and at Lawrence, compiled by R. A. Hale, are printed in this report.

## APPLICATIONS FOR MEMBERSHIP.

[December 5, 1916.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Babcock, John Brazer, 3d, Watertown, Mass. (Age 27, b. Boston, Mass.) Graduate of Mass. Inst. of Technology, 1910, civil engineering course, degree of S.B. From 1910 to 1911, assistant engineer on maintenance, with Grand Trunk Railway, Toronto, Canada; from 1911 to 1912, instrumentman on construction, with Canadian Pacific Railway, Perth, Ontario; from 1912 to 1913, resident engineer, Southern New England Railway, Milliville, Mass.; from 1913 to 1914, resident engineer with Ambursen Hydraulic Construction Company of Canada, on construction of hollow reinforced concrete dams; from 1914 to 1915, designing engineer with same company; during winter of 1915–16, engineer-assistant, Terminal Commission, Boston, Mass.; is now instructor in civil engineering at Mass. Inst. of Technology. Refers to C. F. Allen, C. B. Breed, J. W. Howard, L. E. Moore and C. M. Spofford.

HORTON, FREEMAN HUDSON, Jamaica Plain, Mass. (Age 19, b. Bradentown, Fla.) Student for one year at North Carolina University, and is now third-year student at Mass. Inst. of Technology. Refers to A. E. Burton, G. L. Hosmer, J. W. Howard, H. B. Luther, A. G. Robbins and G. E. Russell.

REED, LESLIE P., Charles River Village, Mass. (Age 26, b. Hyde Park, Mass.) Student at Lowell Inst. for Industrial Foremen from 1910 to 1911, and at Franklin Union, 1913. From September, 1908, to March, 1916, assistant to William S. Johnson, in office, on surveys, and on construction; is now assistant superintendent with Bay State Dredging & Contracting Co., Boston, on Wellesley Extension, Metropolitan High Level Sewer, Needham, Mass. Elected a junior, March 19, 1913, and now desires to be transferred to grade of member. Refers to F. S. Bailey, C. R. Gow, W. S. Johnson and J. E. Palmer.

SAWYER, GEORGE SUMMERS, Fall River, Mass. (Age 26, b. Charlestown, Mass.) Graduate of Mass. Inst. of Technology, 1912, civil engineering course. From 1912 to 1914, assistant in civil engineering department, Mass. Inst. of Technology; from June, 1914, to date, assistant engineer with H. K. Barrows on construction and topographical survey work. Elected a junior, October 21, 1914, and now desires to be transferred to grade of member. Refers to H. K. Barrows, C. B. Breed, J. F. A. Leonard, C. A. Moore and A. L. Shaw.

TOMASELLO, JOSEPH A., Dorchester, Mass. (Age 29, b. Messina, Italy.) Educated in Boston public schools. From 1903 to date, with A. G. Tomasello; began as timekeeper on construction, and since 1908 has been superintendent of construction and partner; is now building bridge at Watertown for Metropolitan Park Commissioners. Refers to R. C. Allen, D. A. Ambrose, C. R. Gow and Hugh Nawn.

## LIST OF MEMBERS.

### ADDITION.

WADE, WM. NEWELL .......... P. O. Box 3215, Boston, Mass.

### CHANGES OF ADDRESS.

BORDEN, J. EDGAR .......... 49 Orchard St., Portsmouth, N. H.
DELONG, HAROLD C. .......... 135 University Rd., Brookline, Mass.
DROWNE, HENRY B. .......... 35 Kimberly Ave., Springfield, Mass.
ELLIS, LESTER F. .......... 52 Waltham St., Lexington, Mass.
FARWELL, JOSEPH W., Jr. .......... Norfolk St., Needham, Mass.
FEHR, GORDON .......... University of Toronto, Toronto, Ont.
GALLENE, VICTOR J. .......... 13–21 Park Row, New York, N. Y.
GLADDING, RAYMOND D. .......... Box 422, Wilson, N. C.
HOLWAY, WM. R. .......... North Scituate, R. I.
HUNTINGTON, FREDERICK W. .......... 14 Appleton St., Lowell, Mass.

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| JEFFERS, ROBERT B. | 55 Beacon St., Rochester, N. Y. |
| JOHNSON, FRANK W. | 822 New Birks Bldg., Montreal, Canada |
| MEAD, ROYAL L. | 125 Prescott St., E. Boston, Mass. |
| POWERS, WM. J., Jr. | 31 Varnum St., Arlington, Mass. |
| SMULSKI, EDWARD | 136 Federal St., Boston, Mass. |
| THOMPSON, SANFORD E. | 136 Federal St., Boston, Mass. |
| WEBB, DEWITT C. | 426 State House, Boston, Mass. |

DEATHS.

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|---|---|
| JAQUES, WILLIAM HENRY | November 23, 1916 |
| PARKER, HAROLD | November 29, 1916 |

## EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

### MEN AVAILABLE.

No. 378. Age 30. Has had International Correspondence School course in mechanical drawing, and is now taking correspondence course in mechanical drafting. Desires work as tracer.

No. 379. Age 35. Experience includes five years as rodman and transitman with Bay State St. Ry. Co.; seven years with Boston Elevated Ry. Co., as transitman, chief of party and inspector of concrete work on construction of Cambridge subway; two years with U. S. Government on survey of Merrimack River and other surveys; five months with Westinghouse, Church, Kerr & Co., as assistant engineer on construction of brick and concrete buildings. Desires position as transitman or draftsman. Salary desired, $80 per month.

No. 380. Age 28. Student at Y. M. C. A. evening school, and at Franklin Union. Experience includes work on Cambridge subway, B. & M. R. R., and with engineering firms. Desires position as rodman. Salary desired, $60 per month.

No. 381. Age 27. Student for three years at Rhode Island State College, mechanical engineering course; graduate of Tri-State Engineering College, civil engineering course. Has had experience as machinist and tool designer, inspector, instrumentman, engineer, draftsman and superintendent; experience includes concrete bridge building and highway construction. Desires position with contractor, as engineer, superintendent, foreman or estimator. Salary desired, $25 as estimator, or $35 per week as engineer, superintendent or foreman.

No. 382. Age 34. Student for three years at Mass. Inst. of Technology, class of 1903. Experience includes four and one-half years with Directors of Port of Boston, chiefly as resident engineer, So. Boston Dry Dock; five and one-half years with Boston Elevated Ry. Co., as assistant engineer; one year with U. S. Army, as civil engineer, on construction work; two years, as draftsman and inspector, with U. S. Navy, Dept. of Yards and Docks. Desires position on construction work, preferably heavy foundations or "water work." Salary desired, $125 per month.

No. 383. Age 27. Graduate of Mass. Inst. of Technology, 1912, civil engineering course. Has had experience as recorder and rodman, U. S. Engineer Office; rodman with B. & M. R. R. and with N. Y. C. R. R.; and as draftsman, timekeeper, foreman and structural iron worker on bridge erection and concrete construction. Desires position as estimator or foreman with contractor near Boston. Salary desired, $35 per week.

## LIBRARY NOTES.

### Recent Additions to the Library.

### U. S. Government Reports.

Buying and Selling of Ores and Metallurgical Products. Charles H. Fulton.

Coal-Tar Products and Possibility of Increasing Their Manufacture in United States. Horace C. Porter.

Economic Surveys of County Highway Improvement. J. E. Pennybacker and M. O. Eldridge.

Some Engineering Problems of Panama Canal in Their Relation to Geology and Topography. Donald F. MacDonald.

Errors in Gas Analysis Due to Assuming that Molecular Volumes of All Gases are Alike. George A. Burrell and Frank M. Seibert.

Financial Statistics of Cities Having a Population of Over 30 000, 1915.

General Statistics of Cities, 1915: including Statistics of Governmental Organizations, Police Departments, Liquor Traffic, and Municipally Owned Water Supply Systems, in Cities Having a Population of Over 30 000.

Gold Log Mine, Talladega County, Alabama.

Lead in 1915. C. E. Siebenthal.

Mica in 1915. Waldemar T. Schaller.

Mining Developments and Water-Power Investigations in Southeastern Alaska. Theodore Chapin and George H. Canfield.

Notes on Prevention of Dust and Gas Explosions in Coal Mines. George S. Rice.

Notes on Some Mining Districts in Eastern Nevada. James M. Hill.

Oil and Gas Geology of Foraker Quadrangle, Osage County, Oklahoma. K. C. Heald.

Permissible Explosion-Proof Electric Motors for Mines; Conditions and Requirements for Test and Approval. H. H. Clark.

Platinum and Allied Metals in 1915. James M. Hill.

Primary Traverse in Illinois, Wisconsin, Minnesota, North Dakota, and South Dakota, 1913–1915. R. B. Marshall.

Primary Traverse in Louisiana and Mississippi, 1913–1915. R. B. Marshall.

Production of Explosives in United States during Calendar Year 1914. Albert H. Fay.

Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.

Specific-Gravity Separation Applied to Analysis of Mining Explosives. C. G. Storm and A. L. Hyde.

Spirit Leveling in Georgia, 1896 to 1914, inclusive. R. B. Marshall.

Spirit Leveling in New Mexico, 1902 to 1915, inclusive. R. B. Marshall.

Sulphur, Pyrite, and Sulphuric Acid in 1915. W. C. Phalen.

Tin Ore in Northern Lander County, Nevada. Adolph Knopf.

Vapor Pressure of Arsenic Trioxide. H. V. Welch and L. H. Duschak.

Water-Supply Paper 393.

**State Reports.**

Massachusetts. Annual Report of Homestead Commission for 1915.

New York. Annual Report of Public Service Commission for First District for 1914, Vols. 1 and 3.

**Municipal Reports.**

Andover, Mass. Annual Reports of Board of Public Works for 1912–15.

Auburn, N. Y. Annual Report of Water Board for 1915.

Boston, Mass. Contract for Constructing High-Pressure Fire Service Distribution System, 1913.

Burlington, Vt. Annual Report of Water Department for 1915.

Chelsea, Mass. Annual Report of Water Commissioner for 1915.

Dover, N. H. Annual Report of Water Commissioners for 1915.

New York, N. Y. Report of Department of Bridges for 1914 and 1915.

**Miscellaneous.**

Activated-Sludge Process in Treatment of Tannery Wastes. Harrison P. Eddy and Almon L. Fales. Gift of authors.

American Society for Testing Materials: Standards, 1916.

American Society of Mechanical Engineers: Transactions for 1915.

Bridge Engineering, 2 vols. J. A. L. Waddell.

Canada, Department of Mines: Investigation of Coals of Canada, Supplementary Report. J. B. Porter.

Clinton Wire Cloth Company: Clinton Handbook on Lath and Plaster; Successful Stucco Houses.

Contracts, Specifications and Engineering Relations. Daniel W. Mead.

Glasgow Iron Company: Catalogue for 1916.

Hydrated Lime Bureau: Ideal Mortar for Brick Masonry.

Typhoid Toll. George A. Johnson. Gift of author.

Last month a number of duplicate copies of magazines, reports, etc., were placed on the ends of the tables in the reading-room. These duplicates were listed in the JOURNAL and members were invited to help themselves. That this material was acceptable to many of our members is shown by the fact that most of it was taken within two weeks after the publication of the list, which fact has encouraged us to continue the work.

As last month, duplicates will be found *on the ends of the reading-room tables.* The list is as follows:

American Society for Testing Materials: Year-Book for 1914, containing Standard Specifications.

Institution of Civil Engineers (London): Vols. 195–198, Parts 1–4, 1913–14; Vol. 200, Part 2, 1914–15.

Massachusetts Gas and Electric Light Commissioners: Annual Report for 1908.

Mass. Inst. of Technology: Contributions from Sanitary Research Laboratory and Sewage Experiment Station, Vols. 2–6, 8.

*Municipal Engineering:* March, 1905–December, 1914; April–September, November, December, 1915; January–April, 1916.

New England Water Works Association: *Journal,* September, December, 1900; 1901–1904; March, June, December, 1905; 1906; March, June, December, 1907; 1908–1909; March, June, September, 1910; 1911–1913; March, June, December, 1914; March, June, December, 1915; March, September, 1916.

United States Census Bureau: Financial Statistics of Cities Having Population of Over 30 000, 1915.

United States Geological Survey: Bulletins 313, Granites of Maine, 1907; 376, Peat Deposits of Maine, 1909; 380, Contributions to Economic Geology, Part I, 1909; 491, Data of Geochemistry, 1911; Water-Supply Papers 3, 15, 20–25, 59, 65, 69, 79–84, 95, 96, 101–104, 110, 113, 114, 122, 143–145, 152, 189, 198, 201, 223, 226, 229, 238, 241, 255, 315.

United States War Dept.: Annual Reports of Chief of Engineers, 1900–1908, 1911–13, Parts 1 and 2, 1915. (1906–8, 1911–13, without appendices.)

A collection of manufacturer's catalogs known as "Catalog Studies" has been placed in the reading-room by the Catalog Equipment and Supply Company. These "Catalog Studies," to quote from the company's own statement, are "the assembled literature of manufacturers of technical merchandise, securely bound in books of convenient size, indexed and placed in a sectional oak filing cabinet."

"Catalog Studies" have been in use in the leading engineering schools of the country for some years, we understand. They are now being asked for by the engineering societies, and the company is installing a set in each of the ten largest cities in the country. We hope they may prove of value to our members.

LIBRARY COMMITTEE.

## NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

**United States Government.** — NAVY DEPARTMENT. — *Navy Yard, Boston.* — Work being done consists of:

Extension central power plant building to provide for air compressor plant, reconstruction of yard railroad track system, and concrete roadway at Naval Hospital, Chelsea.

**Commonwealth of Massachusetts.** — METROPOLITAN PARK COMMISSION. — The following work is in progress:

*Charles River Reservation.* — Building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown. A. G. Tomasello, contractor.

Building reinforced concrete bridge over the Charles River at Commonwealth Ave., Newton and Weston. T. Stuart & Son Company, contractor.

*Mystic Valley Parkway.* — Grading extension of Mystic Valley Parkway from Mystic St. to Medford St., Arlington. James H. Fannon, contractor.

*Nantasket Beach Reservation.* — Building concrete retaining and bulkhead walls southeasterly from roller-coaster. Hugh Nawn Contracting Company, contractor.

*Old Colony Parkway.*— Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge.

**Boston Transit Commission.** — The Dorchester Tunnel has been practically completed from its beginning at Tremont St. to a point under Dorchester Ave. near Broadway in South Boston.

Work is progressing on the Broadway station, which extends in Dorchester Ave. from Broadway to West Fourth St. The T. A. Gillespie Co. is the contractor.

Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is in progress. Coleman Brothers are the contractors.

Section H and Section H Extension, which are completed, extend in Dorchester Ave. from Old Colony Ave. to near Dexter St.

The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to near Ralston St., and embracing the station in Andrew Sq., is being constructed. The T. A. Gillespie Co. is the contractor.

The relaying of the granite block paving, with grout joints and on a concrete base, in Dorchester Ave. from Old Colony Ave. to Humboldt Place, near Andrew Sq., is in progress. The T. A. Gillespie Co. is the contractor.

**City of Boston.** — Public Works Department, Highway Division, Paving Service. — Work is in progress on the following streets:

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| Gaffney St., | from Commonwealth Ave. to B. & A. R. R. | Asphalt. |
| Augustus Ave., | from Metropolitan Ave. to Ethel St. | Bituminous macadam. |
| Washington St., | from Morton St. to Asticou Rd. | Granite block. |
| Bardwell St., | from South St. to Ballard St. | Asphalt. |
| Hillcrest St., | from Elgin St. to Temple St. | Asphalt. |
| Lorette St., | from Centre St. to Hillcrest St. | Asphalt. |
| Temple St., | from Ivory St. to Spring St. | Asphalt. |
| Dunster Rd., | from Centre St. to Pond St. | Asphalt. |

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| Vista St., | from Augustus Ave. to Malvern St. | Bituminous macadam. |
| Granada Ave., | from Metropolitan Ave. to Ethel St. | Asphalt. |
| Cedric St., | from Magazine St. to Langdon St. | Asphalt. |
| Homestead St., | from Humboldt Ave. to Elm Hill Ave. | Asphalt. |
| Amory St., | from Centre St. to Bragdon St. | Granite block. |
| Dearborn St., | from Albany St. to Dudley St. | Asphalt. |
| Dorchester Ave., | from Savin Hill Ave. to Freeport St. | Granite block. |
| Hill Top St., | from Granite Ave. to Hallet St. | Bituminous macadam. |
| Columbia Rd., | from Edward Everett Sq. to Dudley St. | Granite block. |
| Everton St., | from Geneva Ave. to Olney St. | Asphalt. |
| Alexander St., | from Bird St. 527 ft. northerly. | Granite block. |
| Eric Ave., | from Savin Hill Ave. northerly. | Asphalt. |
| Lithgow St., | from Talbot Ave. to Wainwright St. | Asphalt. |
| Harwood St., | from Willowwood St. to Lucerne St. | Asphalt. |
| Upland Ave., | from Park St. to Melville Ave. | Asphalt. |
| Orchardfield St., | from Dorchester Ave. to Freeport St. | Asphalt. |
| Centervale Pk., | from Upland Ave. to Bourneside St. | Asphalt. |
| Epping St., | from Washington St. to Norfolk St. | Asphalt. |
| Westwood St., | from Richfield St. to Wales Pl. | Asphalt. |
| Theodore St., | from Morton St. to 618 ft. northerly. | Asphalt. |
| Morton St., | from Norfolk St. to N. Y., N. H. & H. R. R. | Artificial stone walks. |
| Albany St., | from Dover St. to Northampton St. | Granite block. |
| School St., | from Washington St. to Tremont St. | Granite block. |
| Devonshire St., | from Adams Sq. to Water St. | Wood block. |
| No. Anderson St., | from Parkman St. to Fruit St. | Asphalt. |
| Parkman St., | from No. Anderson St. to No. Grove St. | Asphalt. |
| Canal St., | from Haymarket Sq. to Causeway St. | Granite block. |
| Ripley Rd., | from Vassar St. to Harvard St. | Asphalt. |

**The Fore River Shipbuilding Co.,** Quincy, Mass., has the following work in progress:

Thirteen submarines for U. S. Navy.
Eight torpedo boat destroyers for U. S. Navy.
Five vessels for the Luckenbach Co.
Two vessels for the Texas Co.
One vessel for the Argentine Government.
One vessel for the Cuba Distilling Co.
Two vessels for the Mexican Petroleum Co.
Two stock steamers.